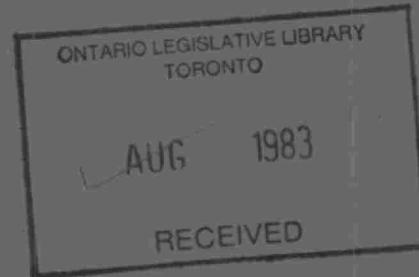


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# AIR QUALITY MARATHON

## Annual Report, 1976.



Ministry  
of the  
Environment

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AIR QUALITY

MARATHON

Annual Report, 1976

ONTARIO MINISTRY OF THE ENVIRONMENT

June, 1977

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## SUMMARY

The Ontario Ministry of the Environment continued with an expanded air quality assessment programme at Marathon in 1976. Soil and vegetation sampling, moss bag exposure experiments, snow sampling, and air monitoring were principal components of the investigations in the vicinity of a kraft pulp mill/chlor-alkali plant complex, which was the main local industrial source of air pollution.

Extremely high mercury concentrations were found in soils near the pulp mill and chlor-alkali plant. Mercury levels decreased rapidly with increasing distance from the mill. An estimated 370 kg (kilograms) of mercury was contained in soils in a 39 ha (hectare)-area near the chlor-alkali plant. Excessive amounts of mercury occurred to depths of at least 20 cm (centimetres) in most severely contaminated soil. Two localized areas of soil contamination were also discovered some distance from the mill.

Acute sulphur dioxide injury to vegetation was noted in a small area of 3 ha in the vicinity of the mill. Elevated mercury levels were also recorded in local vegetation and in moss exposed at many sites near the mill. The pattern of distribution for mercury in moss was similar to that for mercury in soil. Moss also contained very high concentrations of calcium, chloride and sodium. These findings were confirmed by chemical analysis of snow samples, which showed high concentrations of calcium, carbon, chloride, mercury, sodium, and sulphate. All evidence supported a conclusion that airborne emissions from the pulp mill and adjoining chlor-alkali plant were the source of all contaminants detected in the area. Concentrations of all contaminants were much lower in the townsite than near the mill.

Dustfall levels in 1975 and 1976 were similar. Mill emissions were not considered to contribute significantly to dustfall in the town area. Highest atmospheric sulphation rates occurred closest to the mill, where values exceeded the Ontario criterion for 3 of 12 months. A special air monitoring survey in May revealed that hydrogen sulphide and sulphur dioxide concentrations frequently

exceeded the Ontario standard in the vicinity of the mill. Mercury levels, while significantly above normal concentrations, were within provincial regulations.

## INTRODUCTION

Air quality assessment investigations, begun at Marathon in 1974 by Ontario Ministry of the Environment, continued in 1976 with a programme which included soil and soil drainage-water sampling, vegetation injury assessment and sampling, moss bag exposure experiments, snow sampling, and monitoring of gaseous and particulate air pollutants. Survey work was concentrated in the vicinity of the principal local industrial source of air pollution, a 500 ton-per-day bleached kraft pulp mill and adjacent mercury-cell chlor-alkali chemical plant. A review of the kinds of potential atmospheric emissions from this industrial complex and results from air quality studies conducted in 1974 and 1975 are contained in an earlier report (1).

## VEGETATION AND SOIL ASSESSMENT

### (a) Soil and Soil Drainage-Water Sampling

A vegetation and soil sampling survey in August, 1975, indicated the presence of mercury contamination in the vicinity of the chlor-alkali plant/pulp mill complex at Marathon. The levels and extent of contamination were more precisely defined following intensive soil sampling in November, 1975. The pattern of distribution of mercury in soil implicated airborne emissions from the chlor-alkali plant as the source of contamination. In 1974 and 1975, soil sample depth was restricted to the top 10 cm (centimetres). In May, 1976, sampling was extended to 15 cm in a network of sample points in the mill area (Figure 1). When data from the May survey showed significant mercury concentrations at this depth, further sampling was conducted in September to a depth of 30 cm at the 10 closest stations. A supplementary soil survey was also carried out at the same time to define the extent of mercury contamination near

site 31, where unexpectedly high levels had been found in May.

For the general survey in May and the site 31 sampling in September, triplicate samples from each location were obtained with a stainless steel corer, 2.5 cm in outside diameter. Surface debris and organic matter was removed prior to each insertion of the corer. A minimum of 10 cores were pooled to form one sample. In the May survey, cores were separated into fractional depths representing 0-5 cm, 5-10 cm and 10-15 cm below the soil surface. The site 31 samples included only surface soil to a depth of 5 cm. Soil cores collected in September at selected points close to the mill were divided into six, 5-cm fractions to a total depth of 30 cm and were obtained with a trowel from a soil profile face prepared with a spade. All sample material for mercury determinations was placed in labelled plastic bags for shipment to Ministry processing and analytical facilities in Toronto.

Soil drainage-water was collected in clean, plastic-capped glass bottles, preserved with one drop of saturated potassium permanganate solution and 1 ml (millilitre) of concentrated nitric acid, and submitted for mercury analysis to the Ministry's Regional Laboratory in Thunder Bay.

Average mercury levels found in triplicate samples of soil in May are summarized in Table 1. The same data were assembled into contour maps (Figures 4-6) using a SYMAP computer programme developed at Harvard University (2). Results confirmed findings from previous surveys and showed that mercury concentrations were extremely high near the chlor-alkali plant and pulp mill, decreased rapidly with increasing distance, and reached normal, background levels in soil at control sampling points 2.5 and 5.4 km (kilometres) from the source of emissions. Mercury content was generally greatest in surface soil and decreased with increasing depth. The distribution pattern of mercury in soil suggested strong influences from local topography and prevailing winds. All evidence supported a conclusion that soil contamination arose through deposition of airborne mercury emitted by the chlor-alkali plant. Assuming that soil mercury levels above 1 ppm (part per million) constituted contamination, it was estimated that the total load of

mercury in the 0-15 cm soil layer in a hillside area of 39 ha (hectares) near the mill was about 370 kg (kilograms).

The distribution of mercury at soil depths to 30 cm is shown in Table 2 for 10 sites close to the chlor-alkali plant. The mercury content of surface soil was about the same in September as that found in May, but concentrations at greater depths were generally lower. The results indicated that mercury levels below the contamination guideline of 1 ppm were usually reached at a depth of 20 cm. Acceptably low concentrations were recorded in the most severely contaminated soil at 25 cm.

Two localized areas of contamination were found outside the area close to the chemical plant/pulp mill. One of these sites, 1400 m (metres) northeast of the mill, was first discovered in early 1975. Surface soil (0-5 cm) was collected in May, 1976, from eight locations at this site. Analytical results for mercury, plotted in Figure 2, revealed that the source of contamination was inside a perimeter fence surrounding the Company's warehouse. The area near the fence was used for temporary storage of drums of mercury-laden waste from the chlor-alkali plant pending burial twice annually at a site outside the town area. Presumably spillage or leakage from the drums had led to localized soil pollution.

Another area of unusually high mercury content in soil, encountered in the May, 1976, survey at site 31, was sampled in more detail in September. Average mercury levels for nine points at and surrounding site 31 are plotted in Figure 3. The data indicate that mercury contamination extended for at least 20 m in all directions from site 31. Further investigation will be undertaken to determine the actual area of contaminated soil at this location.

Mercury concentrations in soil drainage-water samples from five locations on the hillside south of the pulp mill/chlor-alkali plant were very low, ranging from 0.1 to 2.0 ppb (parts per billion) (Table 3). These limited results therefore suggested that surface water run-off was not a mechanism of significant mercury loss from contaminated soil near the mill.

## (b) Vegetation Injury and Sampling

Vegetation in the vicinity of the pulp mill was inspected for symptoms of air pollution injury at monthly intervals in late June, July and August. To assess mercury content in local vegetation, samples of cow-parsnip (*Heracleum lanatum*), a local weed, were obtained in late July from seven sites near the mill. Each sample comprised about 500 g of fresh leaf and stem material, which was placed in a labelled, perforated polyethylene bag and transferred to refrigerated storage pending air shipment to processing and analytical facilities in Toronto. To determine whether mercury contamination was associated with particulate matter, half of each cow-parsnip sample was washed for 30 seconds in 1 l (litre) of distilled water containing 0.05% Na<sub>4</sub> EDTA plus 0.05% Alconox, followed by 3, 10-second rinses in distilled water.

Vegetation displaying foliage with acute symptoms of sulphur dioxide injury was noted on the hillside to the northwest of the pulp mill. In late June, the affected area was estimated to be 2.4 ha and injury was generally rated as moderate to severe (>16% leaf area damaged). Plant species affected were white birch, speckled alder, blueberry, fireweed and bunchberry. By late July, the injury zone had increased slightly to about 3.0 ha and included some vegetation with trace to light injury (1-15% leaf area affected). The 1976 injury zone (Figure 7) was about a third larger, and in a different location, than injury recorded in 1975 (1). Vegetation damage in the vicinity of the mill was attributed to the effects of SO<sub>2</sub> emissions, estimated as up to 25 tons-per-day, from the mill's power boiler stacks.

Although acute sulphur dioxide damage to vegetation is usually readily identified, vegetation near the Marathon mill might also be suffering from the presence of other potentially injurious emissions, such as chlorine, hydrogen sulphide, mercury, and particulate matter. The adverse effects of these contaminants, if any, would be difficult to diagnose.

Average mercury concentrations in cow-parsnip are shown in Figure 8. Highest levels occurred where soil mercury contamination

was most severe. Since not washed values did not exceed those for washed, contamination had not arisen through deposition of significant quantities of airborne particulate matter. Mercury content in cow-parsnip at all sites near the mill was significantly greater than that for control samples. The latter contained an average of <0.1 ppm and 0.1 ppm for not washed and washed samples, respectively.

### (c) Moss Bag Exposure

Mosses have been found effective in absorbing and retaining airborne contaminants (3) and techniques have been developed for suspending moss in bags as passive monitors of the atmospheric environment (4). In an experimental survey at Marathon, moss bags were exposed for three, one-month periods from late May to late August, 1976, at 25 sites near the pulp mill and at two remote control locations (Figure 9). Each sample consisted of 3 g (grams) of oven-dried Sphagnum moss in a 10 x 20 cm envelope of fibreglass screening which was attached with adhesive tape to a supporting structure about 2.5 m above ground level. Prior to oven-drying, half the samples were washed in distilled water and half in 0.5 molar nitric acid. Acid washing was carried out with the intention of stripping away any contaminants present and to encourage a higher rate of contaminant deposition and retention. Since results obtained with acid washed moss were not significantly different from those with distilled water washed moss in the first set of samples, only the former were used for the second and third sample sets. Following exposure, all samples were submitted to the Ministry's Laboratory Services Branch, Toronto, for analysis of calcium, chloride, mercury and sodium content.

Table 4 and Figures 10 to 13 present chemical analysis results for moss. Levels of all four contaminants investigated were very high close to the pulp mill/chlor-alkali plant and decreased rapidly with increasing distance. All displayed distribution patterns similar to those found for mercury in soil (Figures 4 to 6). The

probable influence of local topography and prevailing wind was evident. Contaminant concentrations were not excessive at site 26 near the town area, 600 m east of the chlor-alkali plant. Levels of all elements were highest in August and lowest in July, but the reason for this variation was not established.

#### SNOW SAMPLING

Snow samples were collected near the mill and in the adjacent town area on three occasions in early 1975. Data from these surveys (1) indicated the presence of an area near the mill containing elevated concentrations of calcium, mercury, sodium and sulphate. Snow contamination by the latter two elements extended into the town area.

More intensive snow sampling was conducted in early 1976, when two sets of samples were collected from 30 locations near the mill, in the adjacent townsite, and at two control points remote from Marathon. A small sub-survey was also undertaken at the north end of the Company's warehouse.

Sample points were selected in undisturbed snow, with preference for areas sufficiently open to permit the free fall of snow, but not subject to excessive drifting. Areas thought to be affected by contaminants from roads or other extraneous sources were avoided. Each site was mapped, and information on site description, snow condition, and snow depth was recorded. The nature and quantity of visible particulate contamination on and below the snow surface was also noted. Each sample constituted a surface area of about 50 by 50 cm and a depth of 20 cm. Snow was collected with a clean plastic shovel, placed in large, heavy-gauge, polyethylene bags, and retained in unmelted condition until processed. Samples were melted indoors in clean plastic pails pre-rinsed with distilled water. Measurement of pH was made as soon as melting was completed (about 12 to 18 hours). Meltwater was then vigorously stirred to suspend particulate matter,

and decanted into clean, 1-litre plastic bottles for submission to the laboratory. Analyses for calcium, chloride, mercury, sodium and sulphate were performed by the Ministry's Thunder Bay Laboratory, and for carbon by the Central Laboratory in Toronto.

Average contaminant concentrations, and pH values, are plotted in Figures 14 to 20. High levels of all parameters were found south of the pulp mill/chlor-alkali plant, with concentrations of sodium and sulphate also being somewhat above normal toward the town area. Elevated pH was attributed to the presence of calcium and sodium salts in the snow. Near the fence at the north end of the warehouse area, mercury concentrations ranging from 0.3 to 16.8 ppb were found in snow at six sites close to the northwest corner of the fence line. The distribution pattern of mercury in snow in this area was the same as that determined from soil sampling (Figure 2).

At sample points near the mill, quantities of visible grey, brown, and black particulate matter were observed on and below the snow surface. The concentration of these contaminants decreased with increasing distance from the mill. At distances of 500 m or more, the snow was clean.

Although no regulations have been promulgated for snow contamination, snow sampling surveys have been found to be useful as indicators of the kind, amount and extent of pollutants around some industrial sources. The adverse effects, if any, of the presence of contaminants in snow has yet to be established. Based on investigations around several northern Ontario kraft pulp mills, guidelines have been established for concentrations of several elements in snow meltwater. Levels above 5 mg/l for calcium, 5 mg/l for chloride, 0.5  $\mu$ g/l for mercury, 10 mg/l for sodium, and 10 mg/l for sulphate are considered as excessive. All guidelines were exceeded in the vicinity of the American Can mill at Marathon, and mercury was also above the guideline near the Company's warehouse.

## AIR MONITORING

## (a) Dustfall

Dustfall, one of the most visible classes of air pollutants, comprises particulate matter which settles out from the atmosphere under the influence of gravity. It is measured by exposing open-top vessels for 30 days and weighing the collected matter. Results are expressed in tons per square mile per month. The soluble and insoluble fraction of dustfall may also be analysed for specific constituents, with results expressed in the same units as for total dustfall.

The 1976 monitoring sites are shown in Figure 21 and dustfall results are summarized in Table 5. Dustfall levels recorded in 1976 were very similar to those for 1974 and 1975. Values at station 63028 were usually well above the Ontario criterion. Dustfall at this site was attributed mainly to dust from a nearby parking area and not to emissions from the mill. Soluble sulphate comprised about 10 percent of total dustfall at all stations except 63027, closest to the mill, where sulphate content was just under 16 percent.

## (b) Sulphation Rate

Sulphation rate is measured by exposing lead dioxide-coated plates to the air for 30-day periods. Lead dioxide reacts with gaseous sulphur compounds in the atmosphere to form lead sulphate. The quantity of sulphate formed is analytically determined and results reported as milligrams of sulphur trioxide per hundred square centimetres per day ( $\text{mg SO}_3/100 \text{ cm}^2/\text{day}$ ). Because of its oxidizing power, lead dioxide also converts reactive compounds other than sulphur dioxide, such as hydrogen sulphide and mercaptans, into sulphate. In Marathon, where more than one sulphur-containing gas may be present, sulphation rates represent the composite effect of all reactive sulphur compounds.

The sulphation monitoring sites are plotted in Figure 21 and results given in Table 5. Sulphation rates were generally higher in 1976 than in 1975. This increase may have been due, in part, to a slight alteration in the procedure for preparing plates prior to exposure. Maximum values were found at station 63031, the site closest to the mill. The Ontario criterion (0.70 mg SO<sub>3</sub>/100 cm<sup>2</sup>/day) was exceeded for four months at this location. Higher sulphation rates were monitored in winter than in summer at all stations, probably because of increased sulphur dioxide levels emitted by heating systems during the winter.

### (c) Source Monitoring Survey

As part of a major survey to monitor contaminant discharges from the pulp mill/chlor-alkali plant and their impact on the surrounding environment, a Ministry of Environment air monitoring van was stationed at Marathon during the week of May 17-21, 1976. The van was equipped to monitor hydrogen sulphide, mercury, nitrogen oxides, sulphur dioxide and total hydrocarbons. During the survey period, the concentrations of these gases were measured at several points close to and remote from the mill area (Figure 22). Depending on wind direction and accessibility, the van was first positioned downwind of the source at the point of expected highest pollutant concentration. Monitoring was then carried out for periods of at least 30 minutes. When feasible, comparable data were subsequently collected for locations at progressively greater distances from the source. Analyser outputs were recorded on strip charts and on punch tape in a data acquisition system.

#### (i) Hydrogen Sulphide

Hydrogen sulphide (H<sub>2</sub>S) and methyl mercaptan (CH<sub>3</sub> SH) are

the principal components of a group of organic sulphide gases commonly emitted by kraft pulp mills. Both are unpleasant smelling at very low concentrations. At higher levels, lead-based paints may be blackened, vegetation may be injured and respiratory irritation may be experienced by human population. An electro-chemical analyser ("Picos") was used for  $H_2S$  measurement at Marathon. This instrument was also sensitive to mercaptan compounds. Monitoring results are presented in Table 6, and an example of data in computer graphic form is shown in Figure 23. Of the total of 34 hours, 6 minutes of data, the Ontario standard of 20 ppb was exceeded for 16 hours, 3 minutes. Downwind of the chlor-alkali plant (sites A and B), relatively low concentrations of  $H_2S$  were recorded. Much higher levels were found in the kraft mill plume(s) at sites C, D and E. The highest half-hour average, 550 ppb, although 27 times greater than the Ontario standard, was not as high as the maximum averages measured downwind of kraft mills in Dryden and Fort Frances. Sites A to E at Marathon were all within 425 m of the mill. Wind conditions did not permit monitoring in the town area. Hydrogen sulphide concentrations slightly above the standard were found at sites as remote as Highway 17, 5400 m from the mill.

#### (ii) Mercury

Mercury is one of the metals with a sufficiently high vapour pressure to exist as a gas in air. Its toxic effects to humans and other animal life have been well documented. In Ontario, a concentration of 5  $\mu\text{g}/\text{m}^3$  has been adopted as a 30-minute standard for airborne mercury in free or inorganic form.

Mercury was monitored with a "Scintrex" analyser which operated as an ultra violet spectrophotometer. The detection limit was 0.005  $\mu\text{g}/\text{m}^3$ . A total of 32 hours, 35 minutes of data were collected in the Marathon survey, and these are summarized in Table 7. A computer graphic example of one monitoring period is shown in Figure 24. At site A, near the chlor-alkali plant, the highest 30-minute average (4.8  $\mu\text{g}/\text{m}^3$ )

and peak value ( $7.0 \mu\text{g}/\text{m}^3$ ) were recorded. The Ontario standard of  $5 \mu\text{g}/\text{m}^3$  was not exceeded at site A or at other locations. The highest concentration coincided with the maximum temperature recorded during the survey, and this result was expected in view of the known sensitivity of mercury concentrations to temperature change. Average and peak levels of mercury declined sharply with increasing distance from the chlor-alkali plant, and approached normal background values at sites F and G.

Mercury monitoring was also conducted near the Company's warehouse, at the clarifier sludge disposal site near the airport, and at the mercury waste burial area, about 3 km southeast of Marathon. At the latter two locations, mercury concentrations near the ground were either below detection limit or at normal background levels. At the warehouse, close to stored drums of mercury-laden waste, mercury concentrations reached a maximum of  $1.0 \mu\text{g}/\text{m}^3$ , which was significantly higher than background levels, but well below the Ontario standard.

### (iii) Nitrogen Oxides

Fuel combustion in stationary sources and in vehicles are the principal man-made sources of nitrogen oxides. Nitrogen oxides are primarily important as precursors to the formation of ozone and other oxidants. At Marathon, the 30-minute Ontario standard was exceeded only once, at site C, as determined by a Bendix 8101-B chemical analyser used for the survey. Most values at all sites were very low. Elevated nitrogen oxide concentrations were associated with elevated sulphur dioxide levels, suggesting that fuel combustion in the kraft mill's power boilers was a source of nitrogen oxide emissions.

## (iv) Sulphur Dioxide

Fuel combustion and industrial emissions are major sources of sulphur dioxide ( $\text{SO}_2$ ), one of the world's major atmospheric pollutants. Many adverse effects of  $\text{SO}_2$  have been documented with respect to human health, vegetation, and corrosion of building materials. In the Marathon survey,  $\text{SO}_2$  was monitored with an "Ultragas - 3" conductivity analyser which was designed so that potential interference from carbon dioxide, hydrogen chloride, chlorine and ammonia was eliminated.

Monitoring results are presented in Table 8, and a graphic example for May 18 is shown in Figure 25. Above-standard concentrations ( $>0.30$  ppm) were measured for nearly a quarter of the total monitoring period. Half-hour averages reached 2.5 ppm, with peaks to 3.8 ppm. Values downwind of the pulp mill (sites C, D and E) were much higher than those downwind of the chlor-alkali plant, thus implicating the former as the principal  $\text{SO}_2$  emission source.  $\text{SO}_2$  levels at the most distant locations (F and G) were well within Ontario regulations.

## (v) Total Hydrocarbons

Like nitrogen oxides, hydrocarbons are much more important in their role in the formation of ozone and other oxidants than they are as toxic agents themselves. Transportation is the principal emitting source, but fuel combustion and industrial process losses may also contribute to hydrocarbon levels in the atmosphere. Many gaseous hydrocarbons are also given off naturally through biological processes, volcanic action and forest fires.

Hydrocarbon measurements at Marathon were made with a flame photometric analyser ("1PM, model RS-SE"). Normally, both methane and non-methane hydrocarbons are determined with this instrument but, because of a malfunction, only total hydrocarbons were monitored.

The Marathon survey revealed that hydrocarbon levels were generally in the 2-4 ppm range, which is considered normal for unpolluted air. Some unexpectedly high values were recorded at site D, during a period when wind direction permitted monitoring of the effluent ditch to the south. No reason for hydrocarbon emissions from this source was apparent.

#### DISCUSSION

Ministry investigations have demonstrated the occurrence of contamination in the vicinity of the Marathon pulp mill/chlor-alkali plant caused by airborne mercury emissions from the chlor-alkali plant. The ultimate fate of mercury in local vegetation and soils is not certain. Studies in the vicinity of chlor-alkali plants have suggested that mercury is emitted principally in elemental, gaseous form and deposited in that form on the surrounding environment (5). It has also been shown that inorganic mercury in soils may be converted to the toxic methylated form (6). Loss of mercury from soil apparently comes about through evaporation to the air, and this thesis will be tested following the closure of the mercury-cell process at the Marathon plant later in 1977.

Direct atmospheric monitoring and moss exposure experiments have both shown that significant quantities of airborne mercury were present on the north side of the chlor-alkali plant, adjacent to Lake Superior. These findings therefore suggest that substantial quantities of emitted mercury may contaminate the waters of the lake as well as nearby vegetation and soils. However, it would be very difficult to establish the relative contribution of mercury contamination in water, lake bottom sediments, and fish arising from airborne sources as opposed to that from mercury discharged in liquid effluent.

## ACKNOWLEDGEMENTS

Contributions and assistance from the following agencies is gratefully acknowledged:

- Instrumentation Development and Monitoring Unit, Technology Development and Appraisal Section, Air Resources Branch, for conducting the air quality survey in May.
- Air Quality Laboratory Section, Laboratory Services Branch, for chemical analysis of vegetation and soil and for preparing and analysing sulphation plates.
- Regional Laboratory, Northwestern Region, for dustfall weight determinations and for chemical analysis of snow meltwater.
- Phytotoxicology Section, Air Resources Branch, for processing vegetation and soil samples.
- Inorganic Trace Contaminants Section, Laboratory Services Branch, for mercury analysis of soil.
- Organic Trace Contaminants Section, Laboratory Services Branch, for carbon analysis of snow meltwater.

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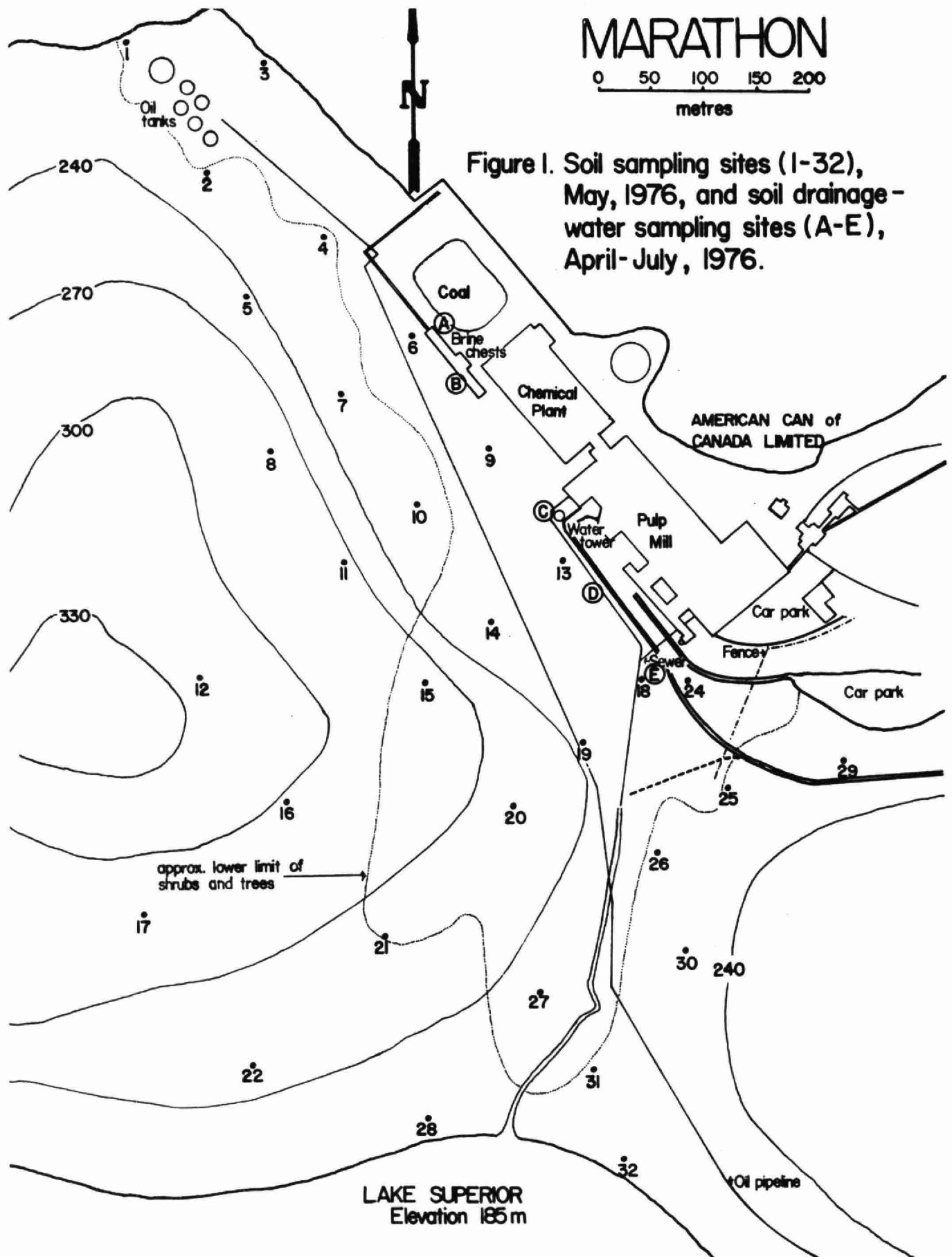


Figure 1. Soil sampling sites (1-32), May, 1976, and soil drainage-water sampling sites (A-E), April-July, 1976.

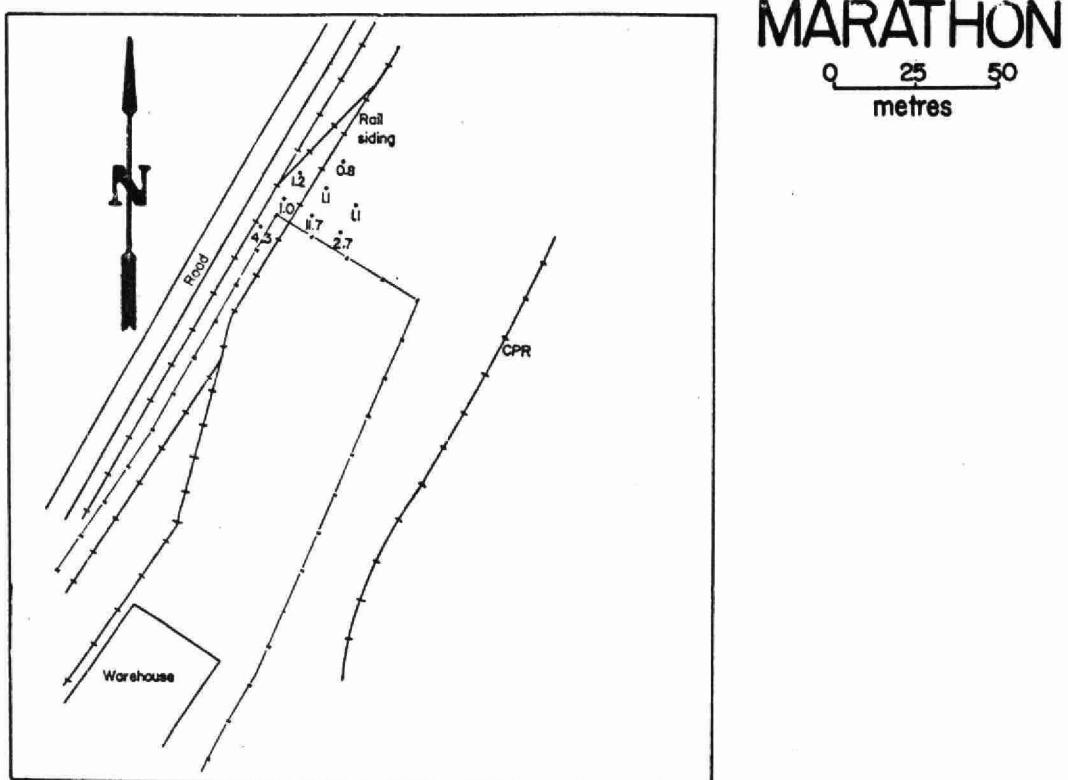


Figure 2. Mercury levels ( $\mu\text{g/g}$ , dry weight) in surface soil (0-5 cm) near warehouse, May, 1976.

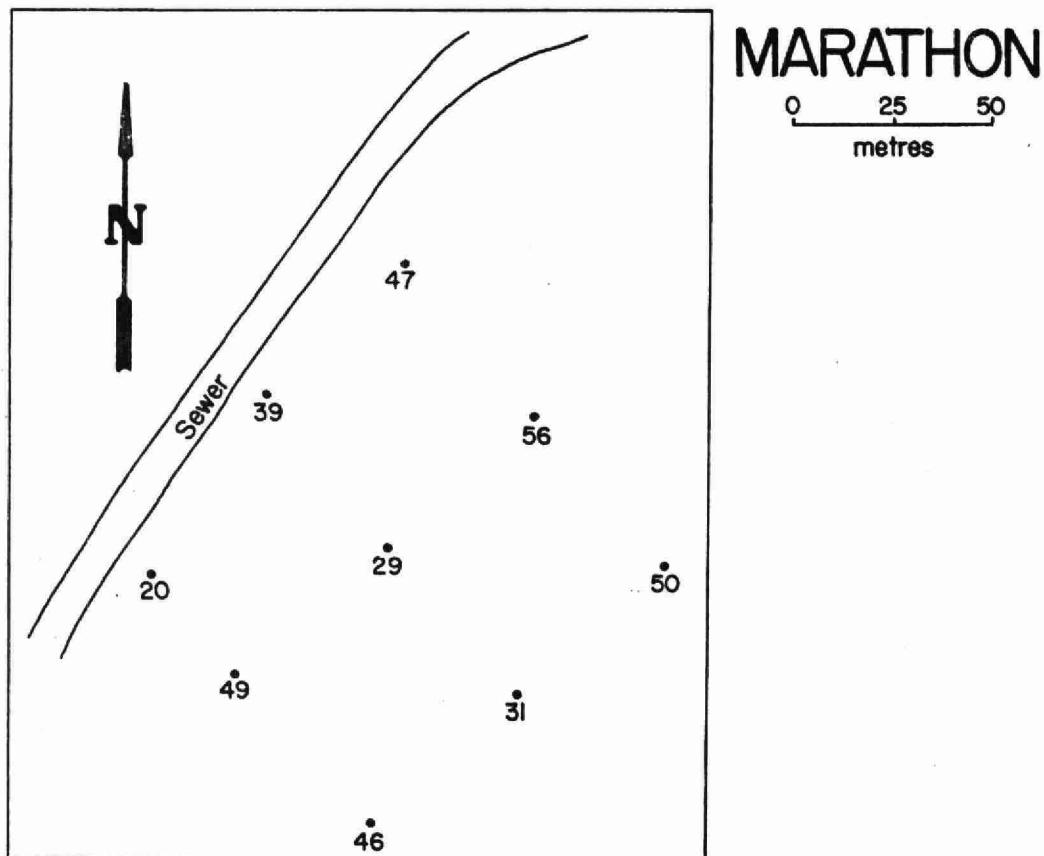
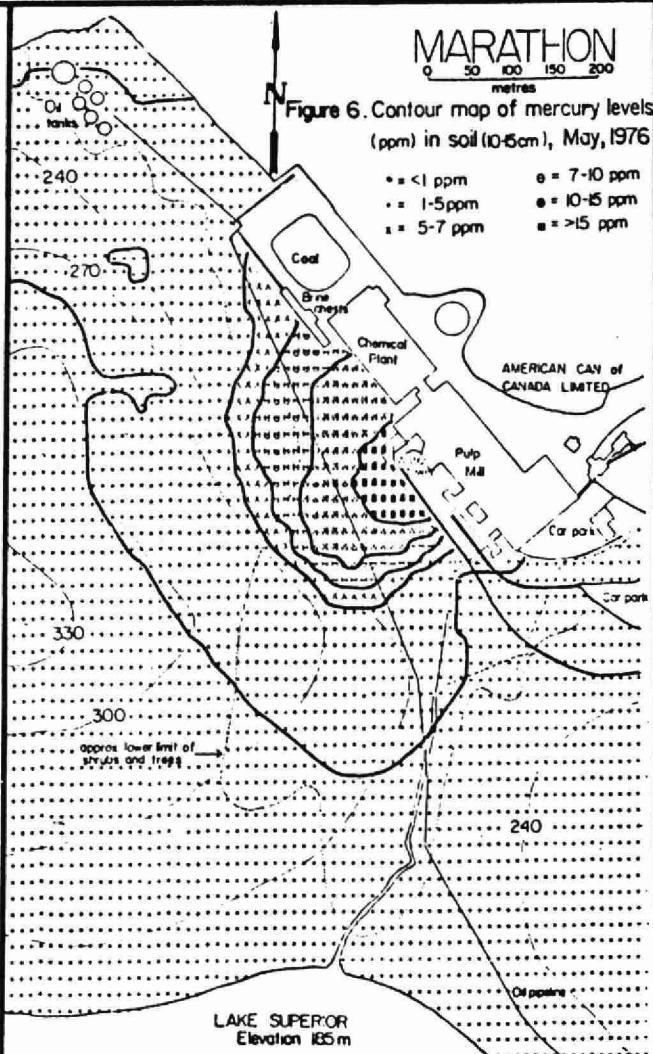
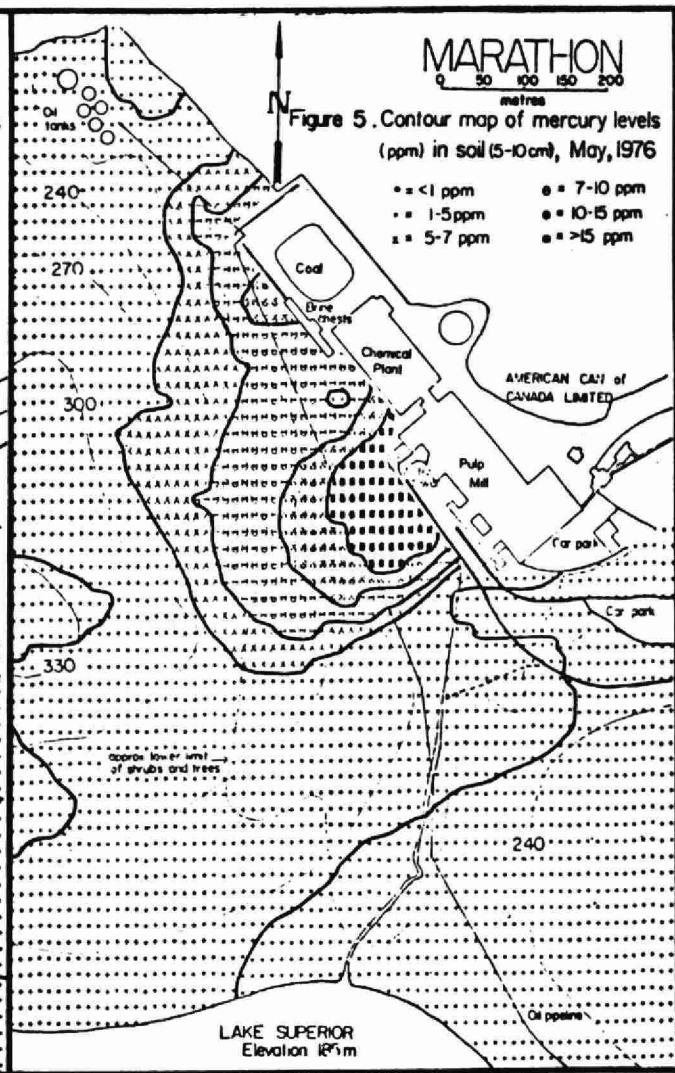
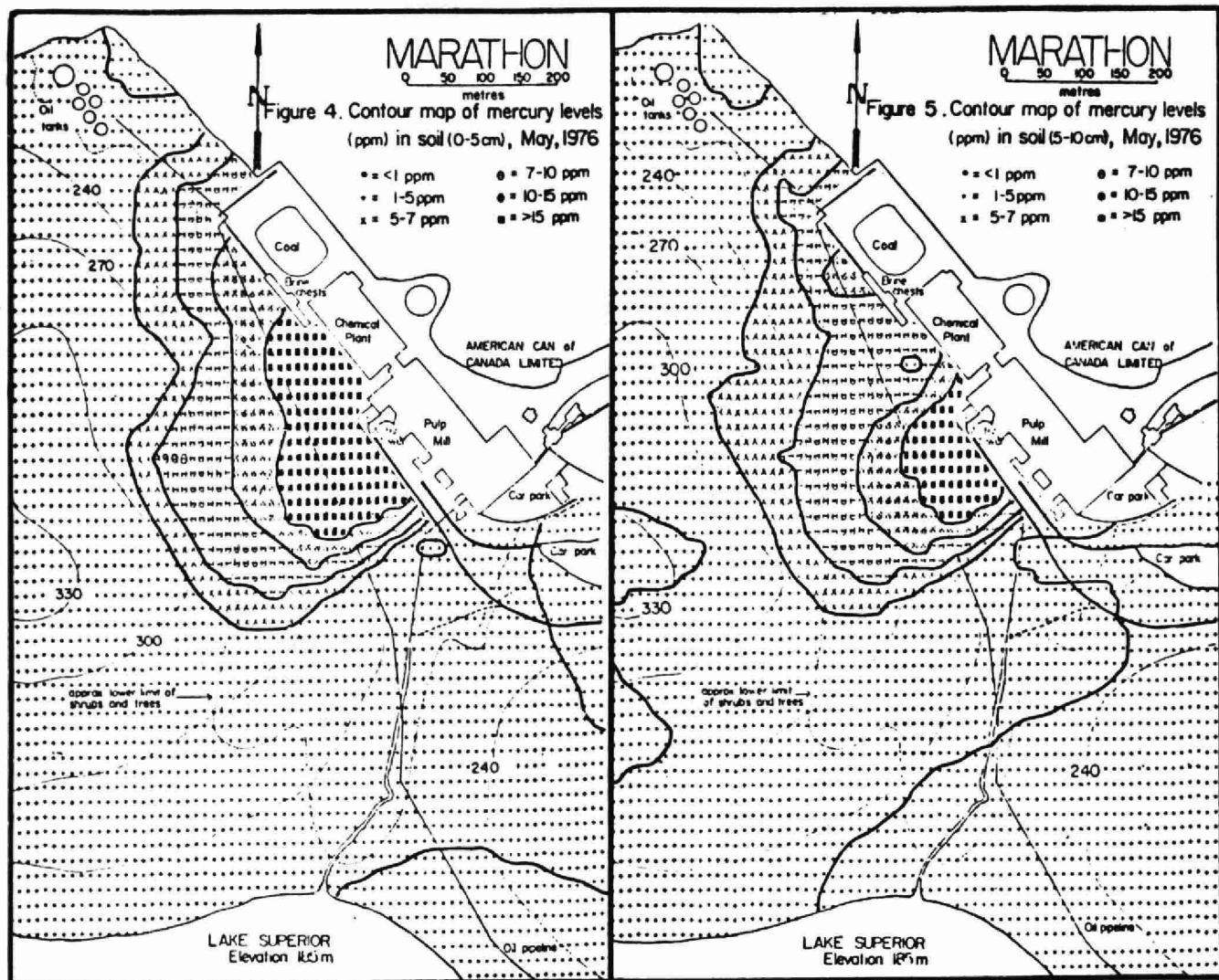
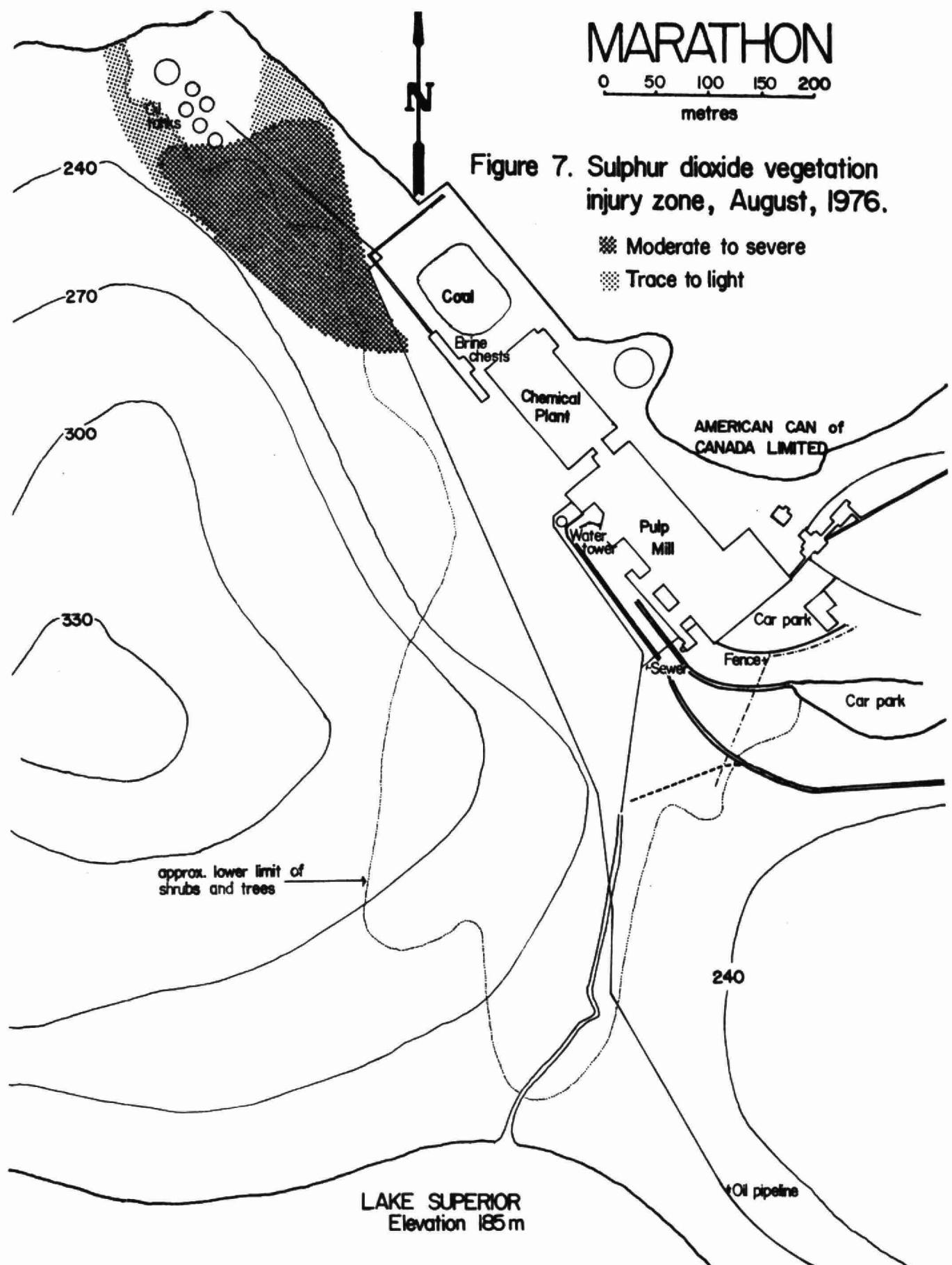
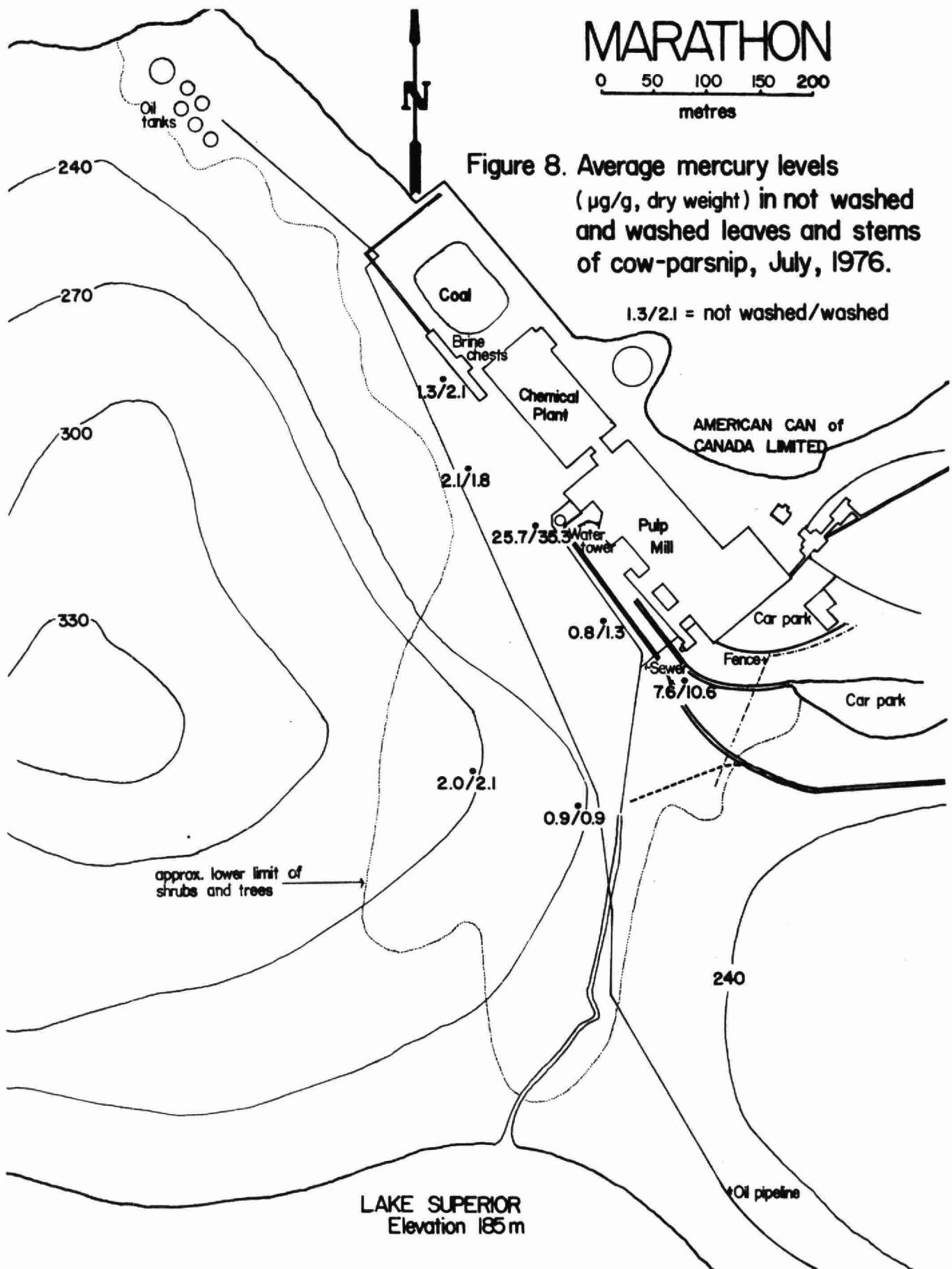
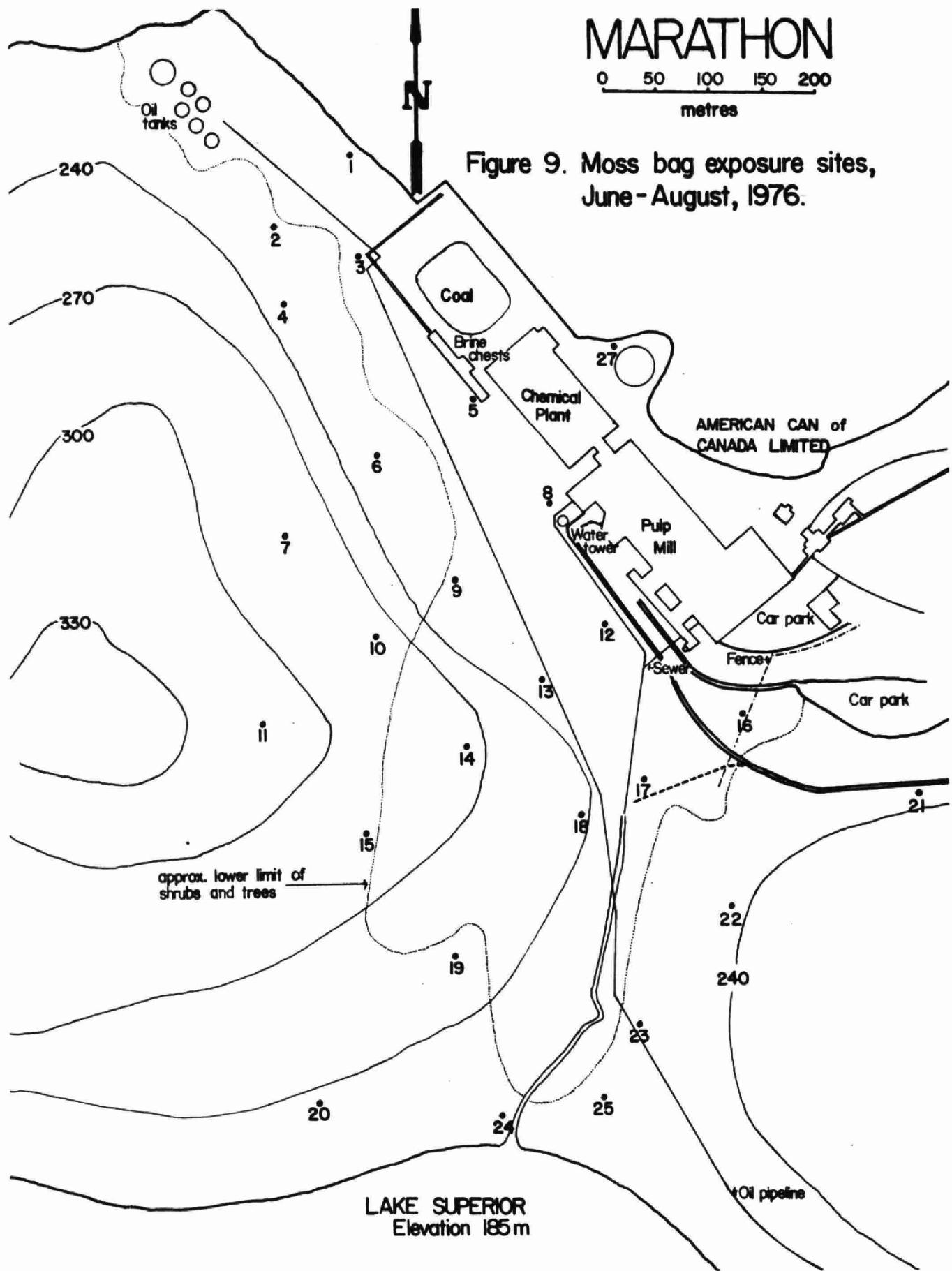


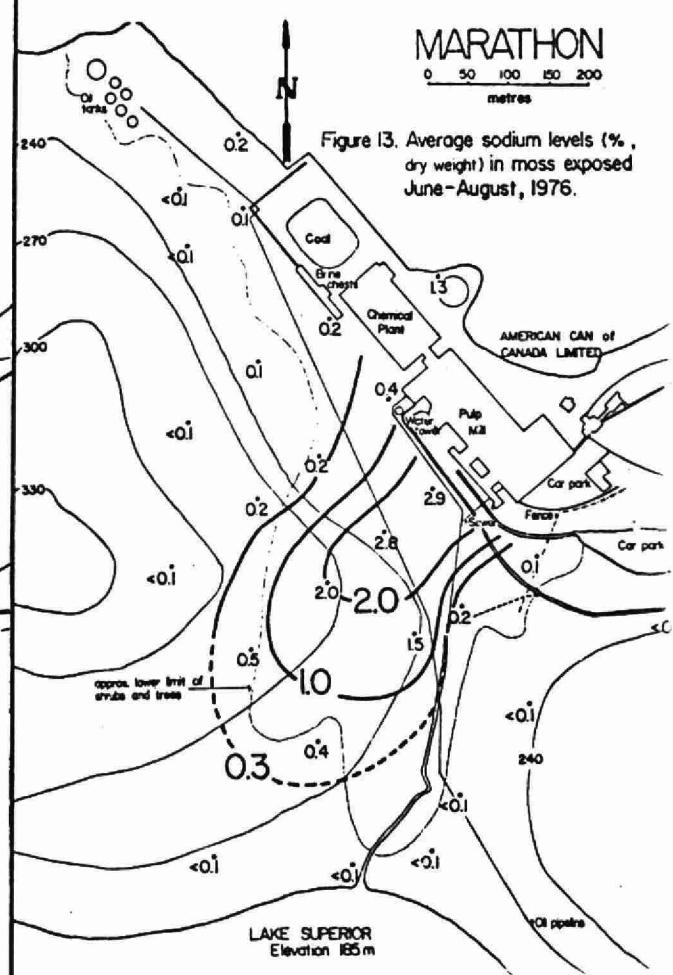
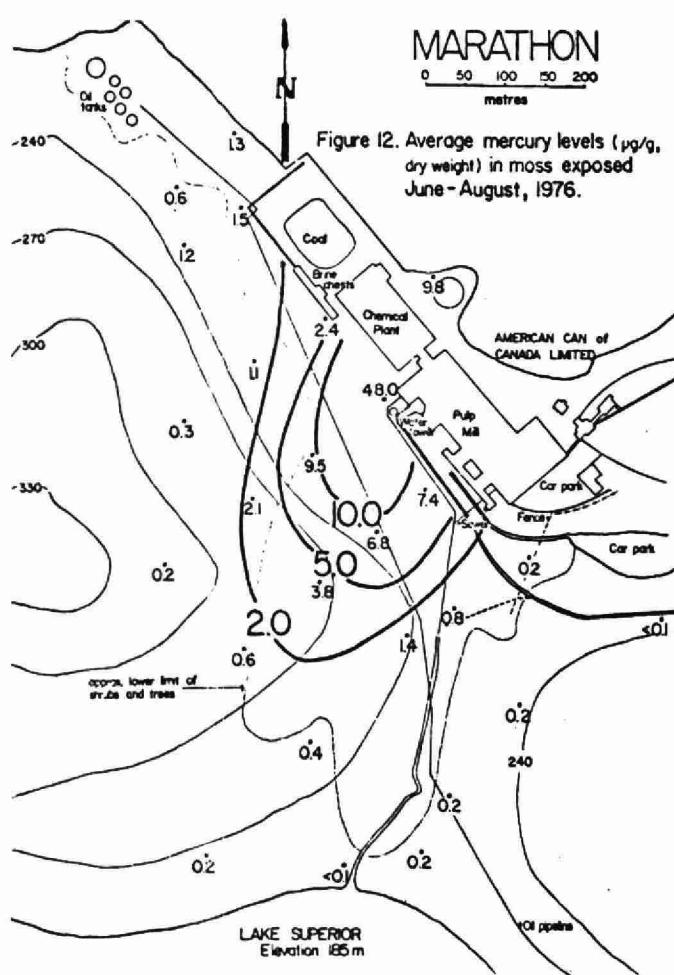
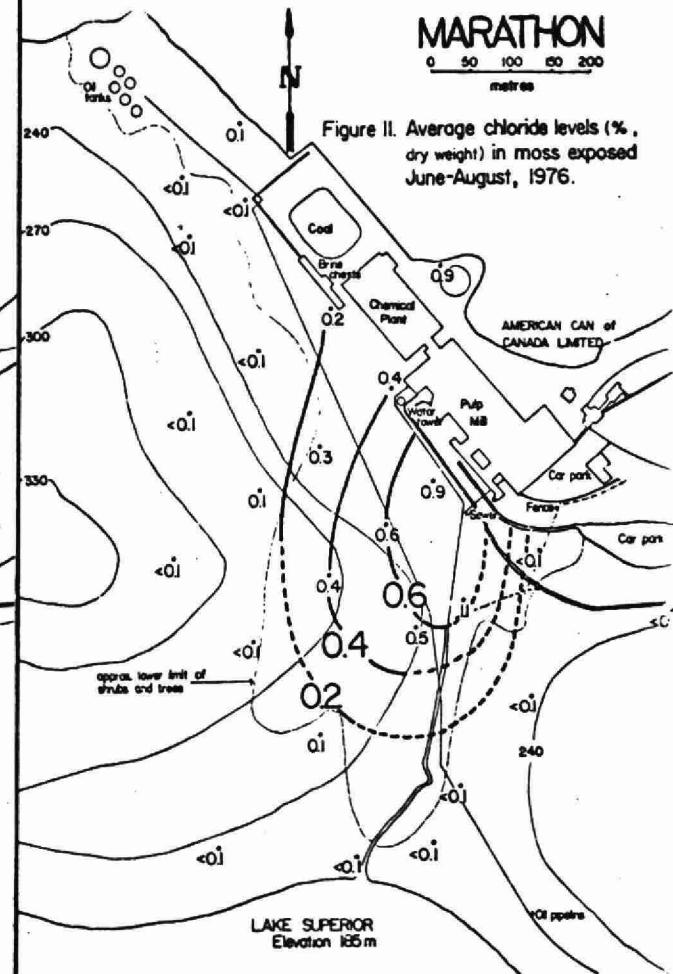
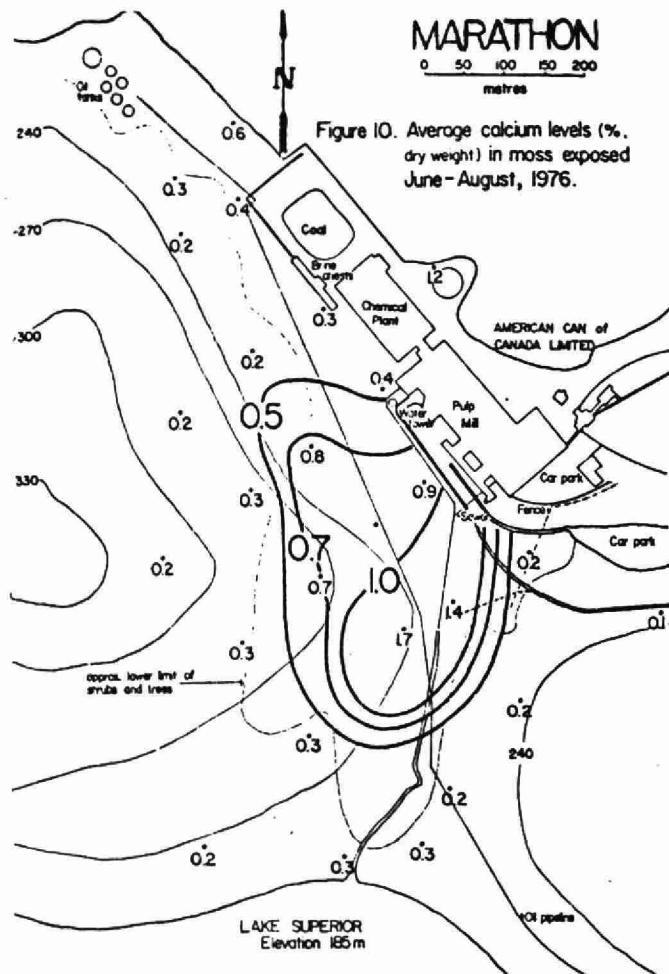
Figure 3. Mercury concentrations ( $\mu\text{g/g}$ , dry weight) in surface soil (0-5 cm) near site 31, Marathon, September, 1976.

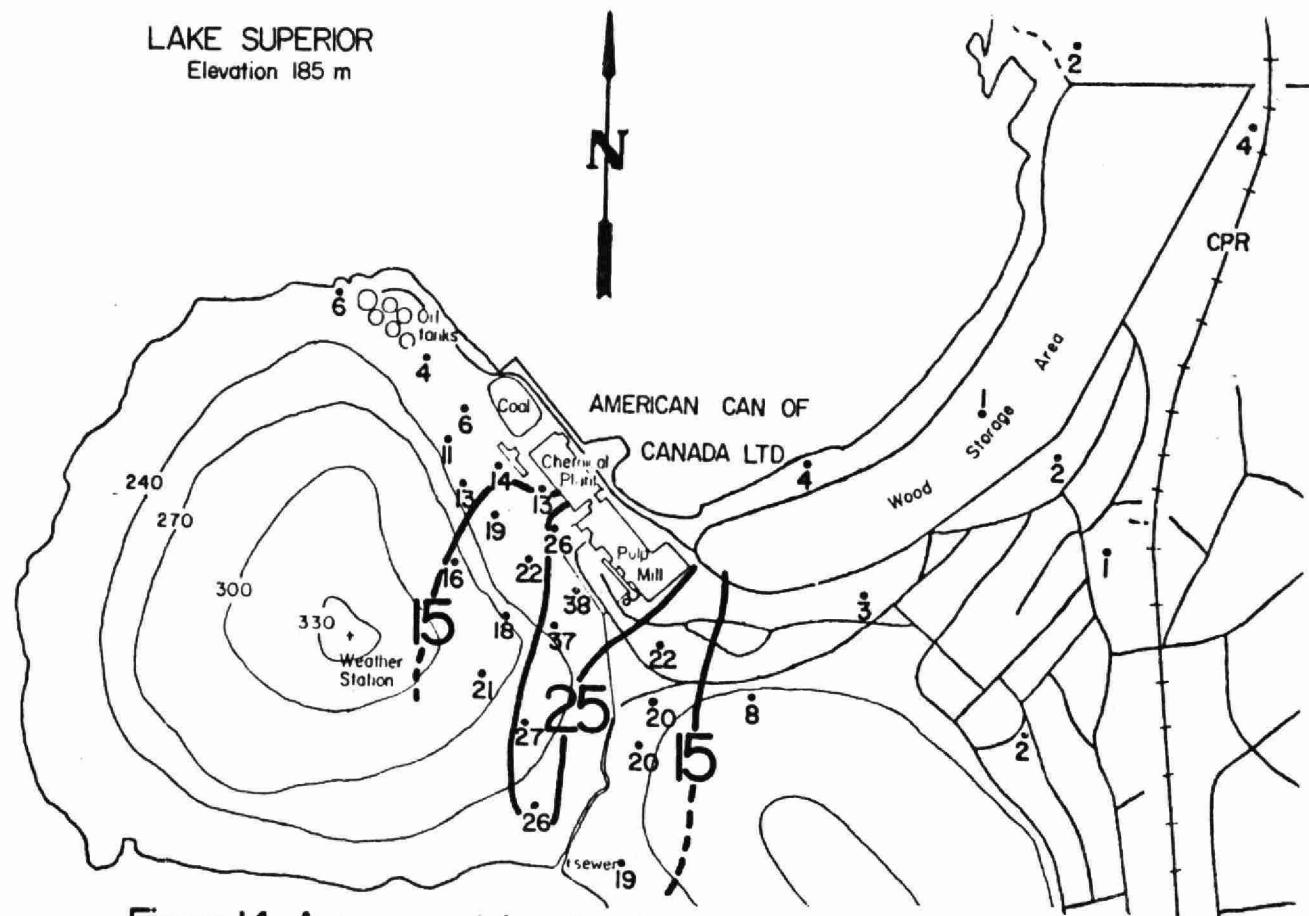












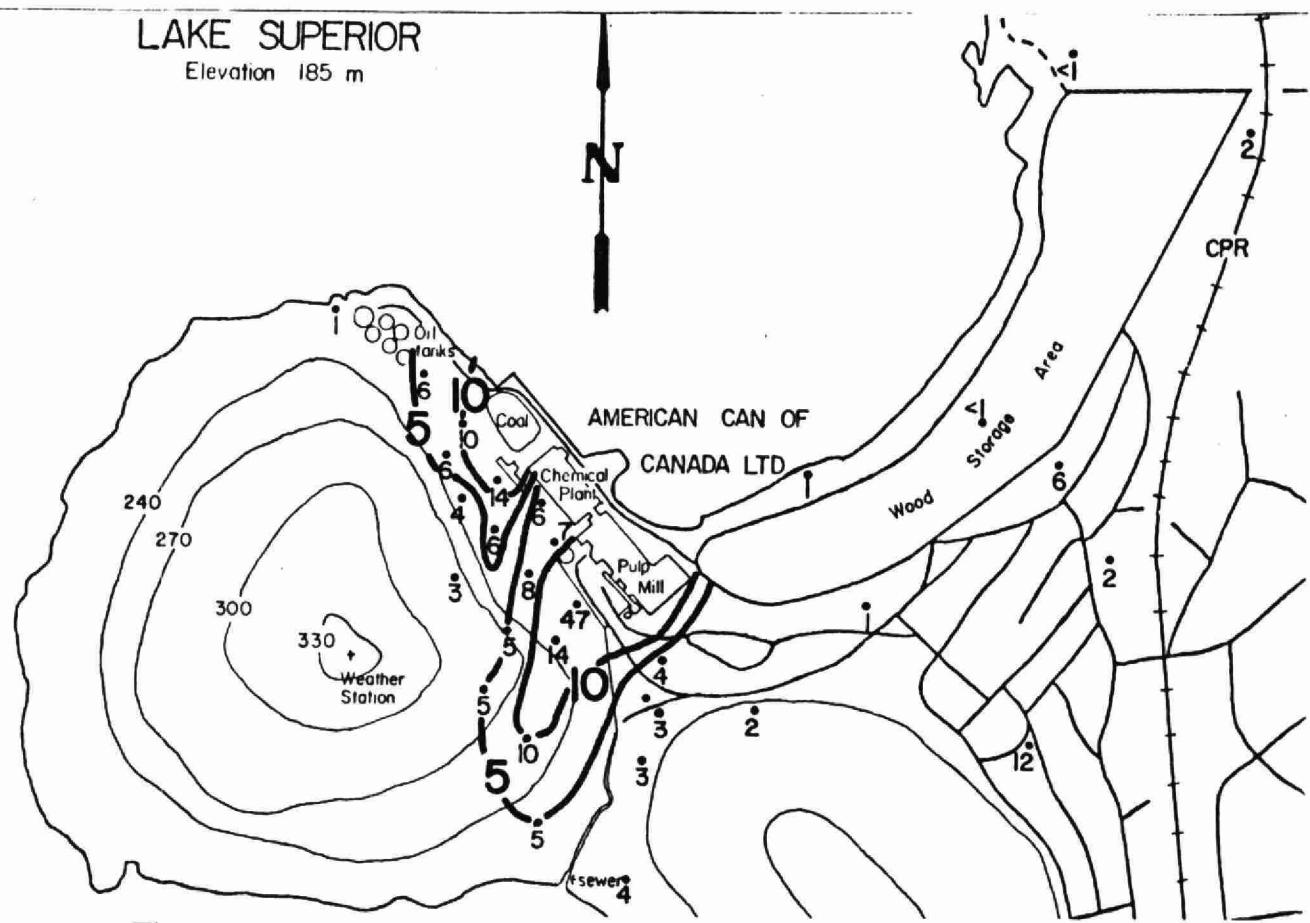


Figure 16. Average chloride levels (mg/l) in snow, January-March, 1976.

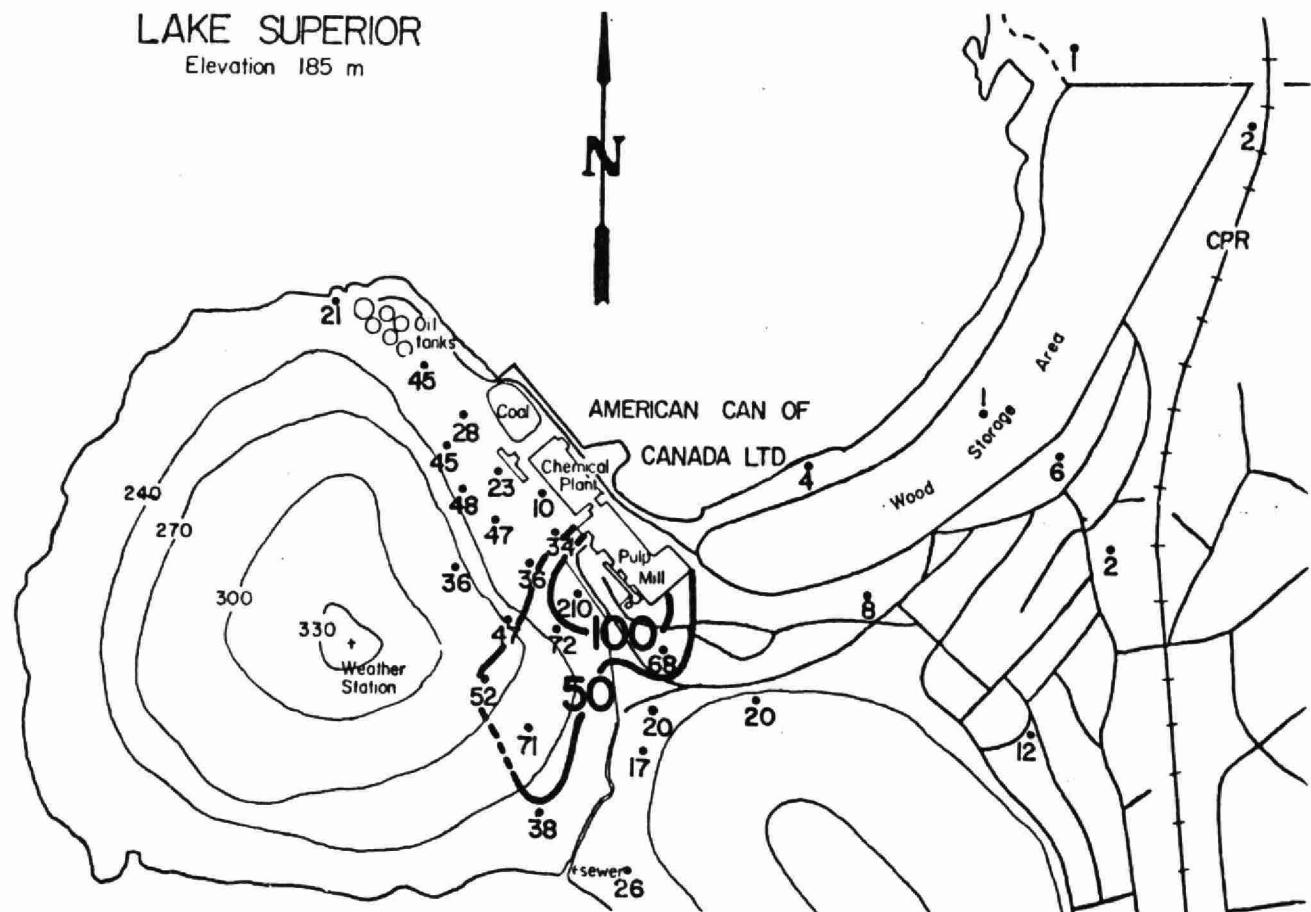


Figure 17. Average sodium levels (mg/l) in snow, January-March, 1976.

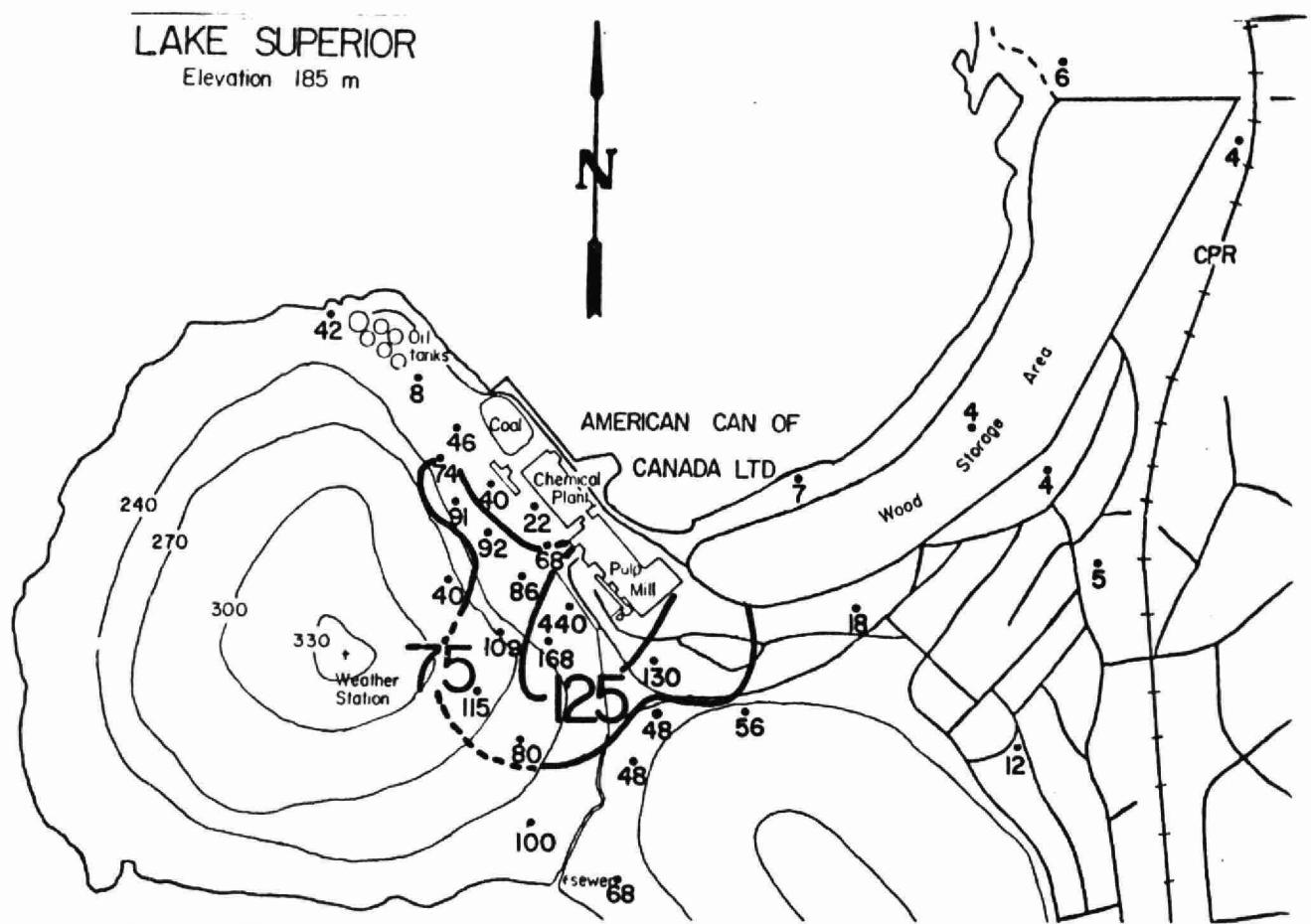


Figure 18. Average sulphate levels (mg/l) in snow, January-March, 1976.

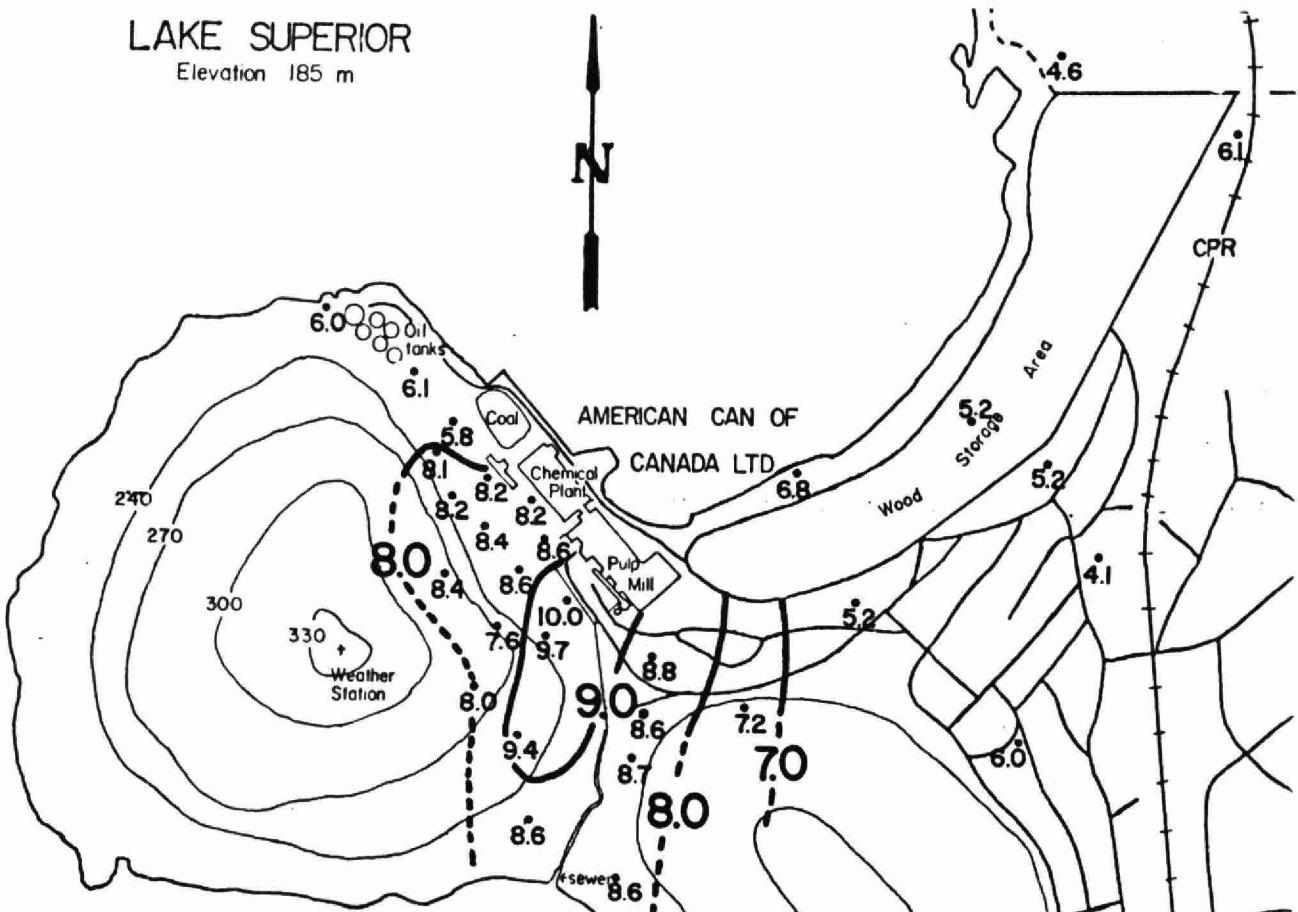
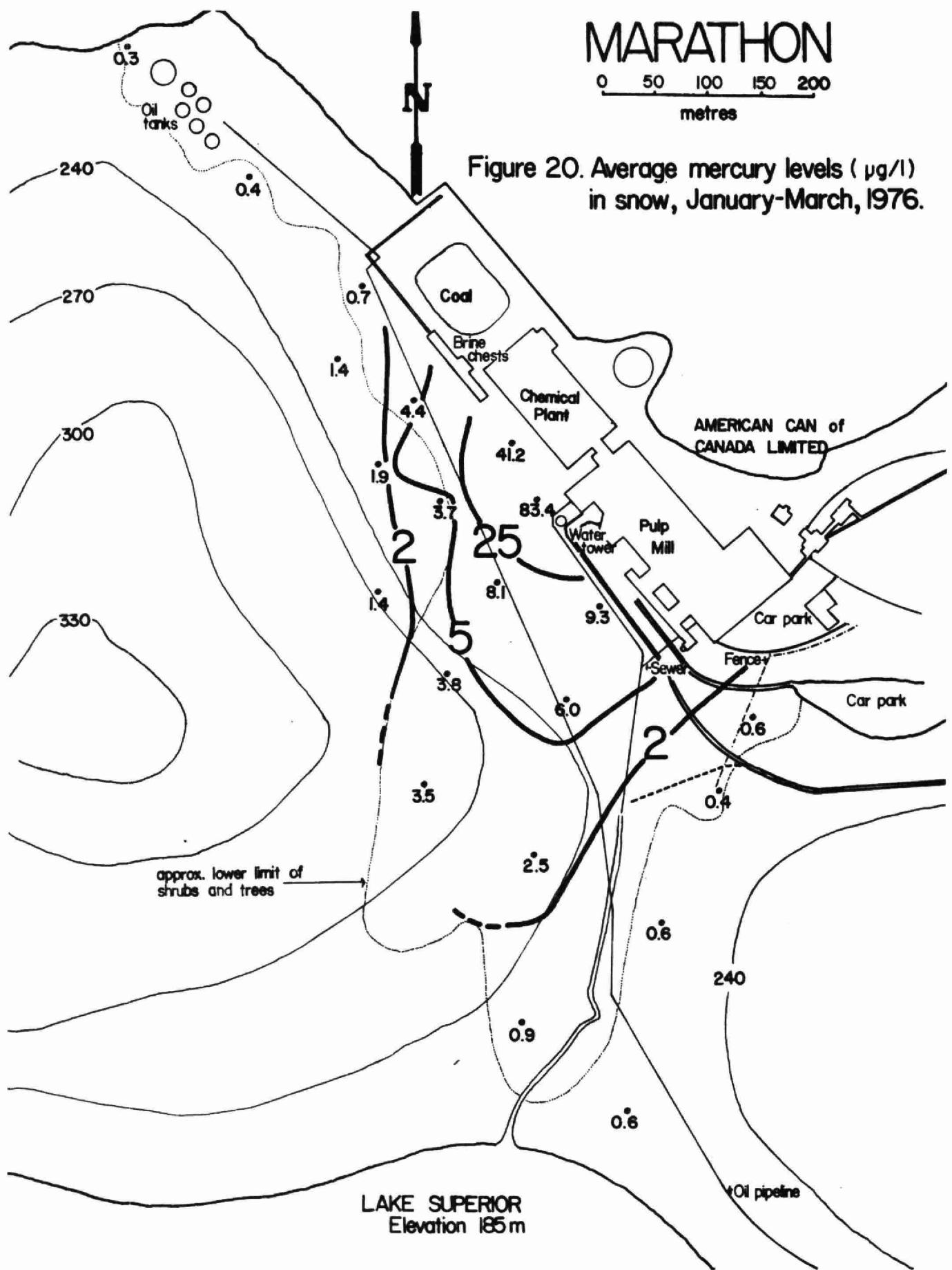


Figure 19. Average pH levels in snow, January-March, 1976.



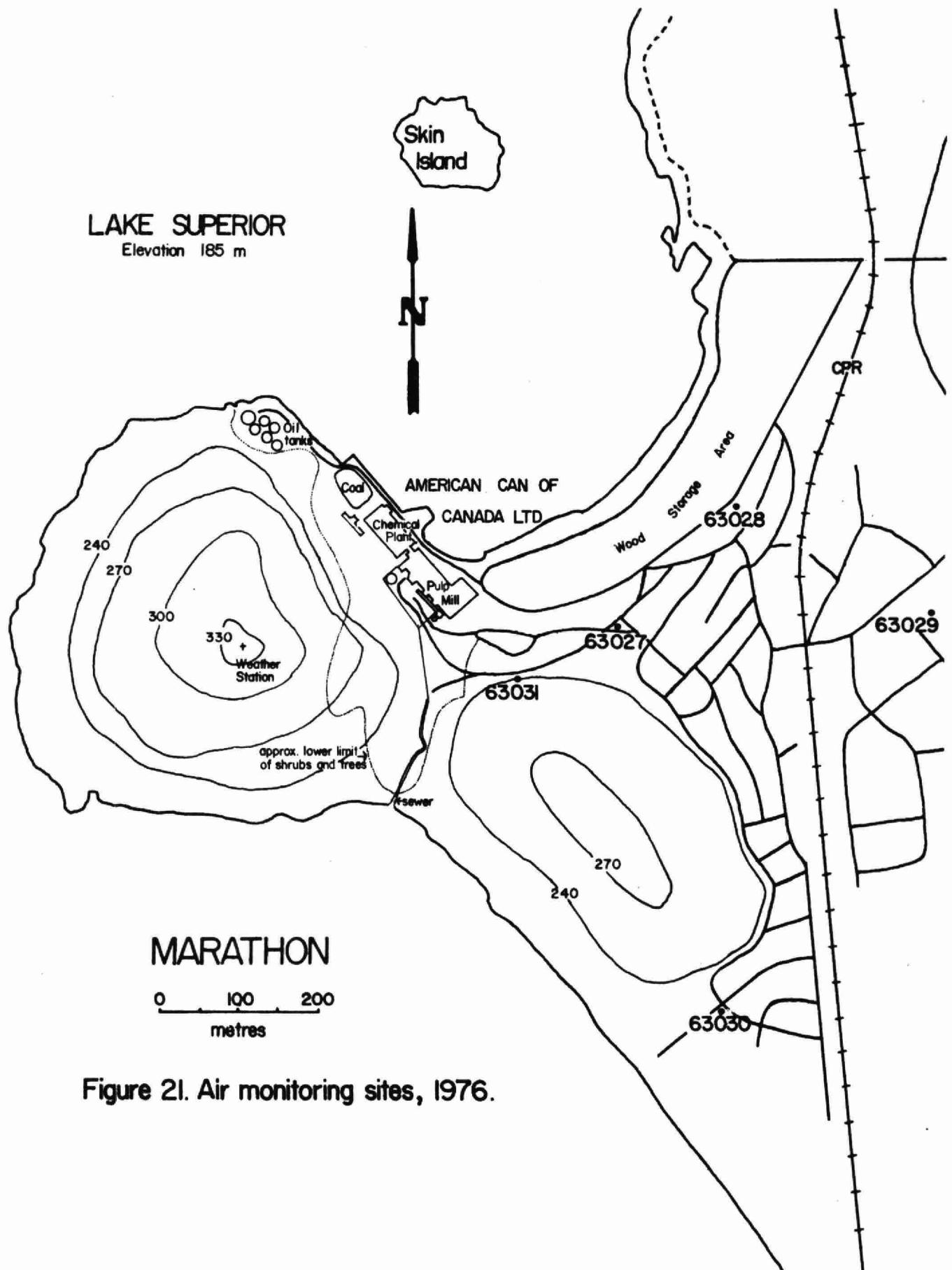


Figure 21. Air monitoring sites, 1976.

# MARATHON

0 500 1000 1500  
metres

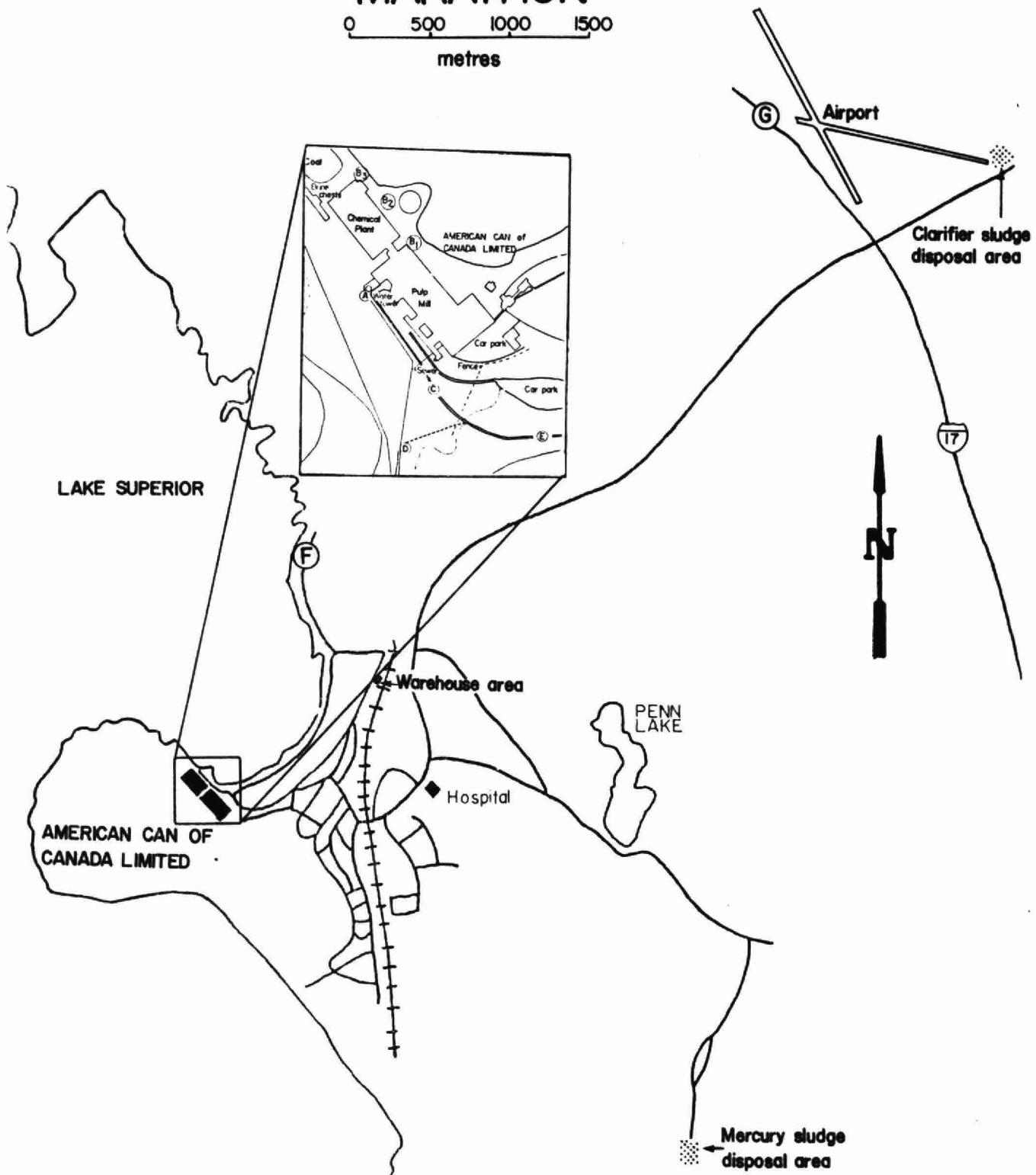


Figure 22. Monitoring sites for air quality survey, May 17-21, 1976.

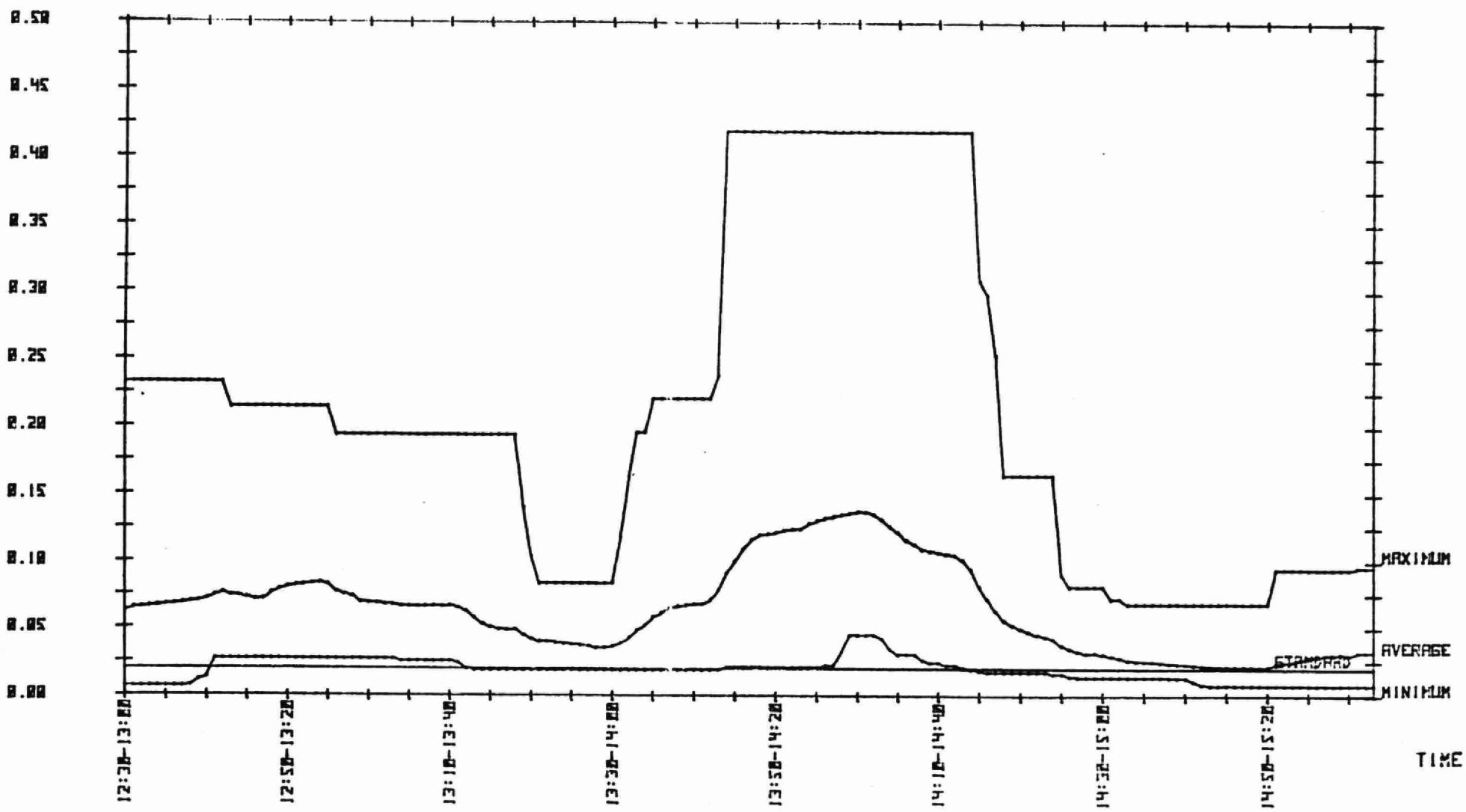
## CONCENTRATION VS TIME

Figure 23.

SURVEY: MARATHON D  
DATE: MAY 10 1976  
SCAN TIME: 60 SEC  
STANDARD: 0.02 PPM  
LOCATION: COMPANY ROAD ON HILL

POLLUTANT: H2S  
START TIME: 12:30  
AVERAGING TIME: 30 MIN  
DISTANCE: .32KM, 170DEG FROM AM.CAN

CONCENTRATION H2S PPM

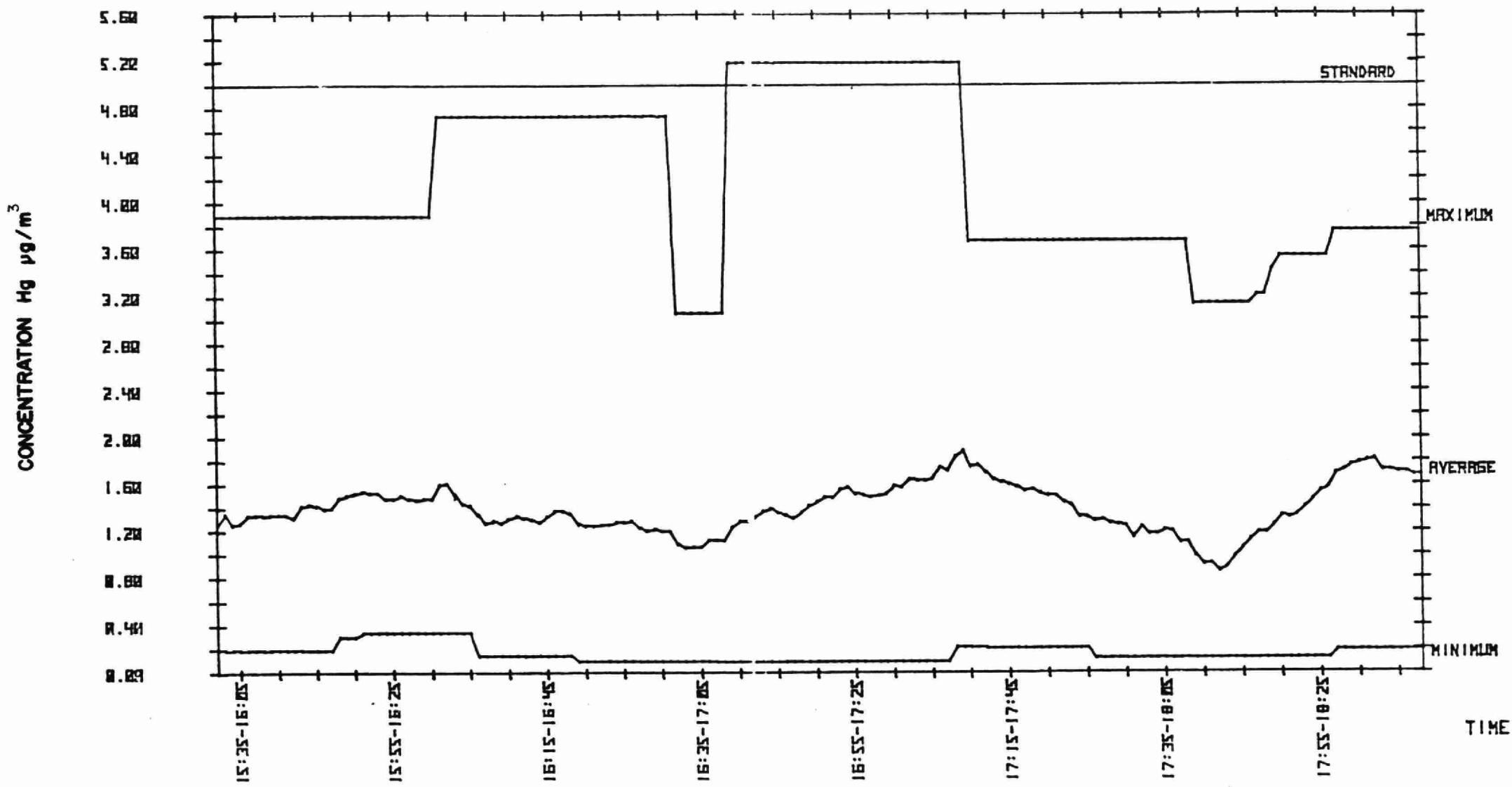


## CONCENTRATION VS TIME

SURVEY: MARATHON #33 ( SITE A )  
DATE: MAY 21 1976  
SCAN TIME: 60 SEC  
STANDARD: 5 UG/ME  
LOCATION: WATER TOWER ( FUNNEL ON CATWALK )

POLLUTANT: HG  
START TIME: 15:32  
AVERAGING TIME: 30 MIN  
DISTANCE: .03KM, 200DEG FROM RM.CAN

Figure 24.

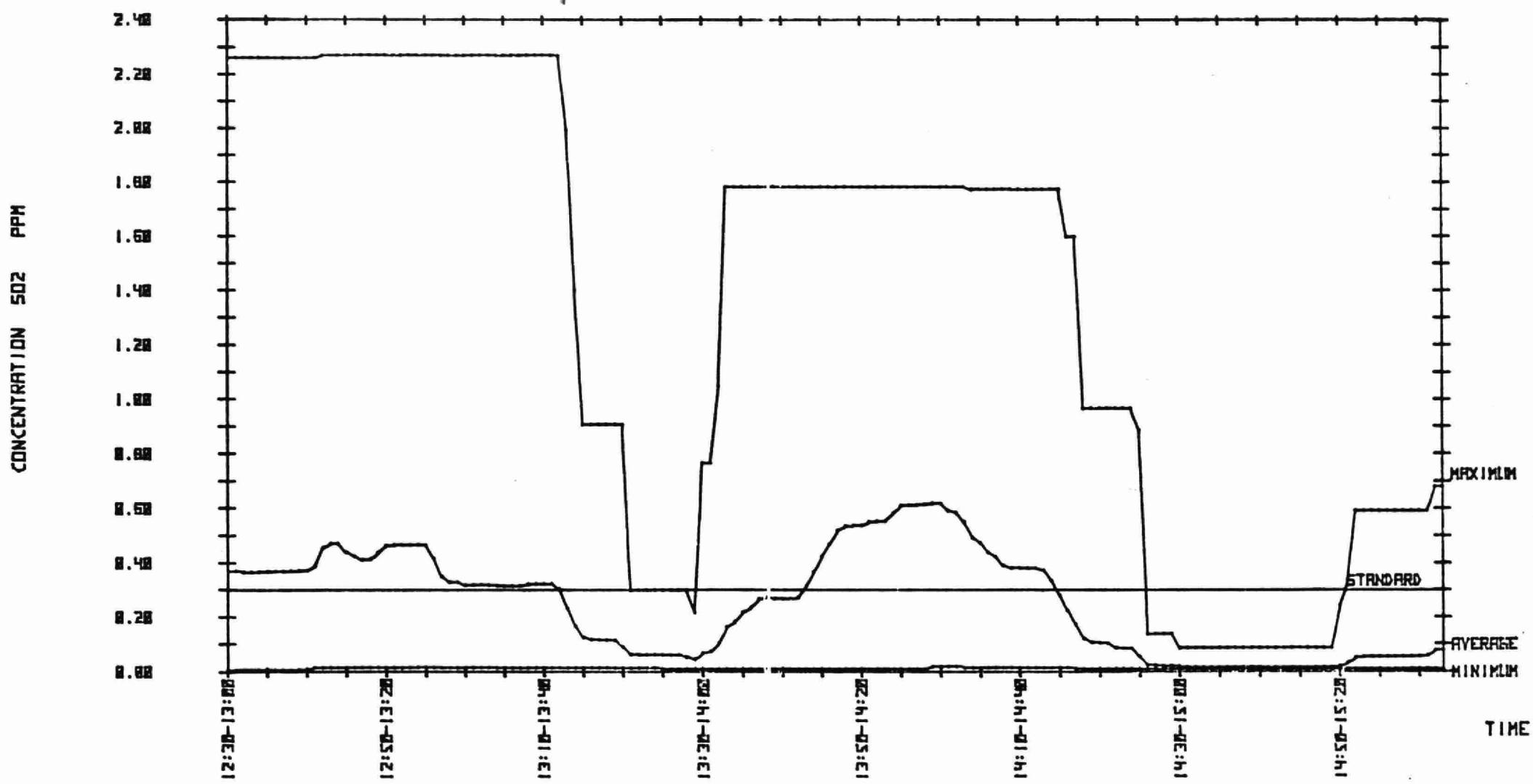


## CONCENTRATION VS TIME

Figure 25.

SURVEY: MARATHON D  
DATE: MAY 18 1976  
SCAN TIME: 60 SEC  
STANDARD: 0.3 PPM  
LOCATION: COMPANY ROAD ON HILL

POLLUTANT: SO<sub>2</sub>  
START TIME: 12:30  
AVERAGING TIME: 30 MIN  
DISTANCE: .32KM, 170DEG FROM RM.CAN



Average concentrations of mercury (ppm, dry weight) in triplicate samples of soil near American Can of Canada Ltd.,  
 TABLE 1. Marathon, May 17-19, 1976.

Site	Distance (metres) and direction from source*	Mercury in soil at depths of		
		0-5 cm	5-10 cm	10-15 cm
1	510 NW	2.3	1.9	0.8
2	375 NW	3.6	2.9	2.9
3	410 NW	0.3	0.1	< 0.1
4	250 NW	7.3	7.0	4.0
5	280 WNW	4.6	2.5	0.7
6	130 WNW	13.6	11.0	5.9
7	175 W	6.6	5.8	3.7
8	250 W	3.1	5.2	0.8
9	50 SW	22.3	6.8	10.8
10	140 SW	10.3	8.8	8.5
11	225 SW	8.8	7.0	3.6
12	395 SW	1.8	0.7	0.4
13	145 S	35.7	32.0	21.0
14	200 S	18.3	14.0	12.6
15	275 SSW	7.6	7.1	2.4
16	430 SW	2.9	2.4	0.4
17	600 SW	2.0	0.9	0.6
18	275 SSE	0.8	0.5	0.4
19	320 S	1.7	2.0	1.7
20	380 S	3.7	2.7	1.6
21	515 SSW	2.8	1.6	0.6
22	670 SSW	2.2	2.1	0.8
23	725 E	0.1	< 0.1	< 0.1
24	300 SE	1.0	0.8	0.6
25	400 SE	1.5	1.3	0.6
26	435 SSE	2.4	1.4	0.8
27	550 S	1.4	0.9	0.5
28	675 SSW	1.0	0.8	0.8
29	450 SE	0.8	0.7	0.2
30	525 SSE	1.2	0.3	0.1
31	625 S	47.5	22.0	6.1
32	710 SSE	0.8	< 0.1	< 0.1
33	930 N	1.1	0.5	0.2
34 (control)	2500 NE	< 0.1	< 0.1	< 0.1
35 (control)	5400 NE	< 0.1	< 0.1	< 0.1

\*Arbitrarily designated as centre of south wall of chlor-alkali plant.

Average levels of mercury (ppm, dry weight) in triplicate samples of soil near American Can of Canada Ltd., Marathon,  
TABLE 2. September, 1976.

Site	Distance (metres) and direction from source*	Mercury in soil at depths (cm) of					
		0-5	5-10	10-15	15-20	20-25	25-30
6	130 WNW	14.0	3.7	0.8	0.5	0.4	0.4
7	175 W	4.8	2.9	0.6	0.4	0.2	0.2
9	50 SW	39.3	3.6	2.7	1.2	0.7	0.4
10	140 SW	14.0	5.2	1.0	0.2	0.2	0.2
11	225 SW	6.1	7.3	3.8	0.6	0.4	0.3
13	145 S	25.3	6.8	0.6	0.3	0.2	0.2
14	200 S	12.0	6.2	1.0	0.4	0.2	0.2
15	275 SSW	4.4	2.4	0.9	0.6	0.3	0.2
19	320 S	3.2	1.8	0.2	< 0.1	< 0.1	0.1
20	380 S	7.7	1.3	0.2	< 0.1	< 0.1	< 0.1
Control	2500 NE	0.3	0.1	< 0.1	< 0.1	< 0.1	< 0.1
Control	5400 NE	0.1	0.3	0.1	< 0.1	0.1	< 0.1

\*Source arbitrarily designated as centre of south wall of chlor-alkali plant.

Mercury content (ppb) in surface run-off water near American  
TABLE 3. Can of Canada Ltd., Marathon, 1976.

Location	Date	Samples collected by	
		American Can	Ministry of Environment
A	April 5	9.0	
	6	2.0	
	8	2.0	2.0
B	July 27		0.4
C	April 5	7.0	2.0
	6	4.0	
	8	3.0	
	23	2.0	
	May 5	4.0	
	14	1.0	
D	April 5	1.0	
	6	< 1.0	
	8	< 1.0	
	July 27		0.1
E	April 5	6.0	
	6	2.0	0.2

TABLE 4. Concentrations (dry weight basis) of calcium, chloride, mercury and sodium in acid washed Sphagnum moss, Marathon, 1976.

TABLE 5. Total dustfall, sulphate in dustfall and sulphation rates, Marathon, 1976.

Station	Location	Distance (metres) and direction from source*	Dustfall (tons/square mile/30 days)												Average
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Dustfall (tons/square mile/30 days)															
63027	McLeod/Abrams	590 ESE	7	11	15	9	17	40	17	11	16	9	9	7	14
63028	Winton/Stevens	875 E	5	18	23 <sup>+</sup>	33	59	38	44	49	39	33	11	4	30
63029	Marathon Shell	1390 E	2	3	14	7	14	17	12	9	14	13	9	2	10
63030	Howe/Yawkey	1390 SE	-	7	10	11	13	-	-	12	12	14	13	11	11
Soluble sulphate (tons/square mile/30 days)															
63027	McLeod/Abrams	590 ESE	2.0	2.4	1.8	1.8	4.6	-	1.4	2.4	2.2	2.4	1.6	2.2	
63028	Winton/Stevens	875 E	1.0	2.5	2.3	2.9	5.6	-	2.0	7.8	2.7	1.8	0.5	2.9	
63029	Marathon Shell	1390 E	0.5	1.8	1.3	1.3	3.0	-	0.6	0.6	1.3	1.2	0.4	1.2	
63030	Howe/Yawkey	1390 SE	1.0	1.0	0.9	0.8	-	-	0.8	1.4	1.7	1.4	0.8	1.0	
Sulphation rate (mg SO <sub>3</sub> /100 cm <sup>2</sup> /day)															
63027	McLeod/Abrams	590 ESE	.58	.36	.20	.11	.18	.16	.10	.10	.21	.22	.16	.31	.22
63028	Winton/Stevens	875 E	.14	.22	.08	.11	.22	.19	.04	.08	.17	.14	.14	.15	.14
63029	Marathon Shell	1390 E	.26	.20	.18	.09	.14	.18	.10	.11	.14	.14	.12	.19	.15
63030	Howe/Yawkey	1390 SE	.32	.36	.24	.08	.20	.12	.06	.06	.14	.16	.14	.23	.18
63031	Bark Press Road	420 SE	<u>.82<sup>+</sup></u>	<u>1.08</u>	<u>.72</u>	<u>.10</u>	<u>.44</u>	<u>.12</u>	<u>.14</u>	<u>.05</u>	<u>.42</u>	<u>.38</u>	<u>.51</u>	<u>.73</u>	.46

\*Source arbitrarily designated as kraft pulp mill recovery furnace stack.

†Values above criteria of 20 (monthly) or 13 (annual average) are underlined.

‡Values above criterion (0.70) are underlined.

Hydrogen sulphide concentrations (ppb) in the air at Marathon,  
TABLE 6. May, 1976.

Site	Date	Period monitored	Concentrations			
			Half-hour averages		Peaks	
			Min.	Max.	Min.	Max.
A	17	15:50 - 16:46	16	29	12	50
		16:47 - 17:49	5	9	2	14
		18:07 - 19:01	0	0	0	0
	18	8:20 - 9:21	8	17	5	27
		17:43 - 18:14	6	6	4	17
	21	8:20 - 9:23	5	8	4	12
		10:00 - 11:07	5	8	5	15
		14:30 - 15:02	18	19	11	34
		15:32 - 18:37	2	14	1	242
		18:43 - 20:26	1	2	1	2
B <sub>1</sub>	19	16:08 - 16:42	21	22	16	34
B <sub>2</sub>	20	11:25 - 11:57	6	6	4	8
		15:15 - 16:16	12	15	5	32
B <sub>3</sub>	20	12:15 - 13:06	1	3	0	6
C	17	9:40 - 10:12	96	110	41	441
		11:00 - 11:45	81	100	48	498
		12:00 - 12:36	120	130	74	418
		14:10 - 15:28	350	550	97	808
		19:27 - 20:28	68	77	50	193
	18	17:55 - 20:29	2	76	1	134
		20:10 - 21:01	150	270	75	502
	18	12:30 - 15:32	21	140	6	419
		16:10 - 16:50	60	63	30	104
		8:50 - 9:50	10	12	9	17
		12:40 - 14:20	30	47	10	126
E	20	17:00 - 17:30	15	15	6	30
		18:20 - 19:21	100	130	30	286
F	20	13:15 - 14:06	20	22	7	43
		14:10 - 14:55	16	19	7	43
G	19	13:18 - 13:48	5	5	0	11
		14:20 - 14:51	13	14	5	18
		17:10 - 18:32	5	26	3	49
	20	9:36 - 10:10	8	9	6	13

TABLE 7. Mercury concentrations ( $\mu\text{g}/\text{m}^3$ ) in the air at Marathon, May, 1976.

Site	Date	Period monitored	Concentrations			
			Half-hour averages		Peaks	
			Min.	Max.	Min.	Max.
A	17	15:50 - 16:46	0.22	0.30	0.08	0.77
		16:47 - 17:49	0.26	0.29	0.08	0.68
		18:07 - 19:01	0.43	0.56	0.12	1.28
	18	8:20 - 9:21	1.40	2.10	0.05	3.28
		17:43 - 18:14	4.80	4.80	2.26	7.04
	20	8:20 - 9:23	0.85	1.00	0.09	2.89
		10:00 - 11:07	0.74	1.10	0.07	3.01
	21	14:30 - 15:02	0.48	0.50	< 0.01	1.39
		15:32 - 18:37	0.86	1.90	< 0.01	5.19
		18:43 - 20:26	0.83	1.80	0.15	4.03
B <sub>1</sub>	19	16:08 - 16:42	0.02	0.02	< 0.01	0.23
B <sub>2</sub>	20	11:25 - 11:57	0.69	0.70	0.26	1.61
		15:15 - 16:16	1.80	2.10	0.17	5.32
B <sub>3</sub>	20	12:15 - 13:06	1.20	1.40	0.32	3.04
C	17	9:40 - 10:12	0.05	0.05	0.01	0.10
		11:00 - 11:45	0.06	0.07	0.02	0.19
		12:00 - 12:36	0.13	0.13	0.02	0.28
		14:10 - 15:28	0.07	0.12	0.04	0.36
		19:27 - 20:28	0.19	0.25	0.08	0.61
	18	17:55 - 20:29	0.28	0.72	0.06	1.99
		20:10 - 21:01	0.44	0.67	< 0.01	1.98
	19	12:30 - 15:32	0.02	0.11	< 0.01	0.29
		16:10 - 16:50	0.08	0.09	0.03	0.36
		8:50 - 9:50	0.08	0.24	0.06	0.50
		12:40 - 14:20	0.09	0.26	< 0.01	0.61
E	20	17:00 - 17:30	0.07	0.07	< 0.01	0.36
		18:20 - 19:21	0.21	0.57	0.01	1.56
F	20	13:15 - 14:06	< 0.01	< 0.01	< 0.01	0.01
		14:10 - 14:55	< 0.01	0.02	< 0.01	0.17
G	19	13:18 - 13:48	< 0.01	< 0.01	< 0.01	0.02
		14:20 - 14:51	< 0.01	< 0.01	< 0.01	< 0.01
		17:10 - 18:32	< 0.01	< 0.01	< 0.01	< 0.01
	20	9:36 - 10:10	< 0.01	< 0.01	< 0.01	0.01

Sulphur dioxide concentrations (ppm) in the air at Marathon,  
 TABLE 8. May, 1976.

Site	Date	Period monitored	Concentrations			
			Half-hour averages		Peaks	
			Min.	Max.	Min.	Max.
A	17	15:50 - 16:46	.03	.03	.03	.04
		16:47 - 17:49	.08	.11	.04	.27
		18:07 - 19:01	.03	.04	.03	.04
	18	8:20 - 9:21	.01	.01	.01	.02
	20	17:43 - 18:14	.02	.02	.00	.07
	21	8:20 - 9:23	.01	.01	.00	.01
		10:00 - 11:07	.02	.02	.20	.08
		14:30 - 15:02	.09	.09	.04	.17
		15:32 - 18:37	.03	.06	.03	.12
		18:43 - 20:26	.02	.04	.02	.05
B <sub>1</sub>	19	16:08 - 16:42	.03	.06	.02	.53
B <sub>2</sub>	20	11:25 - 11:57	.05	.05	.03	.08
		15:15 - 16:16	.05	.07	.03	.16
B <sub>3</sub>	20	12:15 - 13:06	.03	.04	.02	.06
C	17	9:40 - 10:12	.01	.01	.01	.05
		11:00 - 11:45	.12	.12	.02	.88
		12:00 - 12:36	.41	.47	.07	1.30
		14:10 - 15:28	.62	1.10	.06	2.12
		19:27 - 20:28	.10	.16	.03	1.52
	18	17:55 - 20:29	.07	.21	.00	1.43
	20	20:10 - 21:01	1.70	2.50	.40	3.84
D	18	12:30 - 15:32	.02	.62	.01	2.27
		16:10 - 16:50	.03	.06	.00	.63
	19	8:50 - 9:50	.00	.03	.00	.05
	21	12:40 - 14:20	.25	.67	.05	2.63
E	20	17:00 - 17:30	.08	.08	.03	.24
		18:20 - 19:21	.63	.81	.05	2.07
F	20	13:15 - 14:06	.09	.10	.02	.18
		14:10 - 14:55	.05	.07	.02	.24
G	19	13:18 - 13:48	.01	.01	.00	.02
		14:20 - 14:51	.04	.04	.01	.06
		17:10 - 18:52	.01	.09	.01	.21
	20	9:36 - 10:10	.03	.03	.03	.05

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